

March 2011

# DEFENSE ACQUISITIONS

## Assessments of Selected Weapon Programs



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## Why GAO Did This Study

This is GAO's ninth annual assessment of Department of Defense (DOD) weapon system acquisitions, an area that is on GAO's high-risk list. The report is in response to the mandate in the joint explanatory statement to the DOD Appropriations Act, 2009. It includes observations on the performance of DOD's 2010 portfolio of 98 major defense acquisition programs; data on selected factors that can affect program outcomes; an assessment of the knowledge attained by key junctures in the acquisition process for a subset of 40 programs, which were selected because they were in development or early production; and observations on the implementation of acquisition reforms. To conduct this review, GAO analyzed cost, schedule, and quantity data from DOD's Selected Acquisition Reports and collected data from program offices on performance requirements and software development; technology, design, and manufacturing knowledge; and the implementation of DOD's acquisition policy and acquisition reforms. GAO also compiled one- or two-page assessments of 71 weapon programs. These programs were selected based on their cost, stage in the acquisition process, and congressional interest.

DOD disagreed with GAO's use of total program cost growth as a performance metric because it includes costs associated with capability upgrades and quantity increases. GAO believes it remains a meaningful metric and that the report explicitly accounts for the cost effect of quantity changes.

View [GAO-11-233SP](#) or key components. For more information, contact Michael J. Sullivan at (202) 512-4841 or [sullivanm@gao.gov](mailto:sullivanm@gao.gov).

March 2011

## DEFENSE ACQUISITIONS

### Assessments of Selected Weapon Programs

## What GAO Found

Since 2008, DOD's portfolio of major defense acquisition programs has grown from 96 to 98 programs, and its investment in those programs has grown to \$1.68 trillion. The total acquisition cost of the programs in DOD's 2010 portfolio has increased by \$135 billion over the past 2 years, of which \$70 billion cannot be attributed to quantity changes. A small number of programs are driving most of this cost growth; however, half of DOD's major defense acquisition programs do not meet cost performance goals agreed to by DOD, the Office of Management and Budget, and GAO. Further, 80 percent of programs have experienced an increase in unit costs from initial estimates; thereby reducing DOD's buying power on these programs.

**Changes in DOD's Fiscal Year 2010 Portfolio of Major Defense Acquisition Programs over the Past 2 Years (Fiscal Year 2011 Dollars in Billions)**

	Estimated portfolio cost in 2008	Estimated portfolio cost in 2010	Estimated portfolio cost growth since 2008 <sup>a</sup>	Percentage growth since 2008 <sup>a</sup>
Total estimated research and development costs	\$407	\$428	\$15	5%
Total estimated procurement costs	1,089	1,219	121	11
Total estimated acquisition cost	1,531	1,680	135	9

Source: GAO analysis of DOD data.

<sup>a</sup>These columns do not include \$6 billion in research and development and \$9 billion in procurement cost changes for the Ballistic Missile Defense System. DOD does not consider these adjustments to represent cost growth because the program has been allowed to add 2 years of new funding with each biennial budget.

GAO continues to find that newer programs are demonstrating higher levels of knowledge at key decision points, but most are still not fully adhering to a knowledge-based acquisition approach, putting them at a higher risk for cost growth and schedule delays. For the programs GAO assessed in depth, GAO found that a lack of technology maturity, changes to requirements, increases in the scope of software development, and a lack of focus on reliability were all characteristics of programs that exhibited poorer performance outcomes.

Last year GAO reported that DOD had begun to incorporate acquisition reforms that require programs to invest more time and resources at the beginning of the acquisition process refining concepts through early systems engineering and building prototypes before beginning system development. Many, but not all, planned acquisition programs are adopting these practices. As GAO has previously recommended, more consistently applying a knowledge-based approach, as well as improving implementation of acquisition reforms, can help DOD achieve better outcomes for its portfolio of major weapon system programs.

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**Abbreviations**

BMDS	Ballistic Missile Defense System
DAMIR	Defense Acquisition Management Information Retrieval
DOD	Department of Defense
IAMD	Integrated Air and Missile Defense
MDA	Missile Defense Agency
NA	not applicable
OMB	Office of Management and Budget
RD&E	research, development, test, and evaluation
SAR	Selected Acquisition Report
TRL	Technology Readiness Level

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**United States Government Accountability Office  
Washington, D.C. 20548**

March 29, 2011

Congressional Committees

I am pleased to present GAO's ninth annual assessment of selected weapon programs. This report provides a snapshot of how well the Department of Defense (DOD) is planning and executing its major defense acquisition programs—an area that is on GAO's high-risk list.<sup>1</sup> It comes at a time when DOD is pressing forward with implementation of the weapon acquisition reforms put in place over the past few years and searching for efficiencies that will allow it to instill fiscal discipline into weapon programs and obtain better buying power for the warfighter and taxpayer. These reforms and efficiency initiatives are consistent with the recommendations we have made over the years emphasizing the need for DOD to acquire greater knowledge about programs' requirements, technology, and design before they start; improve the realism of cost estimates for both ongoing and new programs; and achieve a balanced mix of weapon systems that are affordable, feasible, and provide the best military value to the warfighter.

To its credit, DOD has demonstrated a strong commitment, at the highest levels, to address the management of its weapon system acquisitions, and the department has started to reprioritize and rebalance its weapon system investments. Since 2009, the Secretary of Defense has proposed canceling or significantly curtailing weapon programs, such as the Army's Future Combat System, which he characterized as too costly or no longer relevant for current operations. Congress's support for several of the recommended terminations indicates a willingness to make difficult choices on individual weapon systems and DOD's major defense acquisition program portfolio as a whole.

The focus of this year's report is slightly different than in years past. We still provide information on the cumulative cost growth experienced by the 98 programs in DOD's 2010 portfolio of major defense acquisition programs, but much of our cost analysis examines program performance over the last 2 years. This allows us to better focus on the department's management of its major defense acquisition programs since key acquisition reforms were put into place by Congress and DOD. In addition, our cost analysis now explicitly accounts for cost growth associated with changes in weapon system quantities, identifies the programs that drive most of DOD's cost

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<sup>1</sup>GAO, *High-Risk Series: An Update*, [GAO-11-278](#) (Washington, D.C.: Feb. 16, 2011).

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growth, and assesses DOD against cost performance goals agreed to by DOD, the Office of Management and Budget (OMB), and GAO.

Our review this year indicates that DOD is making decisions that put most new or planned programs in a better position to succeed, but still faces challenges to effectively managing its current weapon system programs. DOD can help assure it delivers the promised return on investment for its weapon system spending by using the knowledge-based acquisition approach that is now embodied in law and policy. Our review this year found continued improvement in the knowledge DOD officials had about programs' technologies, designs, and manufacturing processes for programs that recently progressed through key points in the acquisition process. However, most programs are still proceeding with less knowledge than best practices suggest, putting them at higher risk for cost growth and schedule delays. In fact, a majority of DOD's major defense acquisition programs did not meet cost performance goals agreed to by DOD, OMB, and GAO for total cost growth over 2-year and 5-year periods and from their initial program estimates. More consistently applying a knowledge-based approach, as well as improving implementation of acquisition reforms, can help DOD achieve better outcomes for its portfolio of major weapon system programs.

While recent acquisition reforms have put newer programs in a better position to field capabilities on-time and at the estimated cost, existing programs such as the Joint Strike Fighter—which began without following knowledge-based acquisition strategies—continue to drive poor outcomes for DOD's major defense acquisition program portfolio. Over the last 2 years, the total acquisition cost of the programs in DOD's 2010 portfolio has grown by \$135 billion (in fiscal year 2011 dollars). About half of this growth can be associated with quantity changes, versus poor management and execution problems, but at least \$70 billion is indicative of such problems. The cost growth on the Joint Strike Fighter alone accounted for almost \$34 billion of that amount. Cost overruns of this magnitude on programs that have already spent years in development can only be meaningfully offset by reductions in planned capabilities or quantities. Serious consideration by DOD of these types of tradeoffs will be essential to getting cost growth under control.

This report provides insights that will help DOD place programs in a better position to succeed, thus helping the department maximize its investments. The current acquisition reform environment, coupled with fiscal imperatives, constitute an opportunity to leverage the lessons of the past

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and manage risks differently. This environment is shaped by significant acquisition reform legislation, constructive changes in DOD's acquisition policy, and initiatives by the administration, including making difficult decisions on individual weapon systems. To sustain momentum and make the most of this opportunity, it will be essential that decisions to approve and fund acquisitions be consistent with the reforms and policies aimed at achieving better outcomes. Such decisions will need the support of both DOD and Congress.

A handwritten signature in black ink, reading "Gene L. Dodaro". The signature is fluid and cursive, with a large, stylized "D" and a long horizontal stroke at the end.

Gene L. Dodaro  
Comptroller General of the United States



United States Government Accountability Office  
Washington, D.C. 20548

March 29, 2011

## Congressional Committees

This is GAO's ninth annual assessment of selected Department of Defense (DOD) weapon programs and the third in response to the mandate in the joint explanatory statement to the DOD Appropriations Act, 2009.<sup>1</sup> This report provides a snapshot of how well DOD is planning and executing its weapon programs—an area that is on GAO's high-risk list. Congress and DOD have long explored ways to improve the acquisition of major weapon systems, yet poor program outcomes persist. In the past 2 years, we have reported improvements in the knowledge programs attained about technologies, design, and manufacturing processes at key points during the acquisition process. However, we have found that most programs continue to proceed with less knowledge than recommended, putting them at higher risk for cost growth and schedule delays. Recent reforms place additional emphasis on applying knowledge-based acquisition practices, which, if implemented, put programs in a better position to field capabilities on time at the estimated cost.

This report includes (1) observations on the performance of DOD's portfolio of 98 major defense acquisition programs, (2) data on factors, such as performance requirements and software management, that can affect program outcomes, (3) our assessment of the knowledge attained by key junctures in the acquisition process for a subset of 40 weapon programs—primarily in development or the early stages of production—from the 2010 portfolio, and (4) observations on the extent to which DOD is implementing recent acquisition reforms.

There are three sets of programs on which our observations are primarily based in this report. We assessed all 98 major defense acquisition programs for our analysis of portfolio performance; 40 programs in development or early production for our analysis of factors that can affect outcomes and knowledge attained by key junctures; and 14 planned major defense acquisition programs for our analysis of DOD's progress in implementing selected acquisition reforms. To develop our observations on the

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<sup>1</sup>See Explanatory Statement, 154 Cong. Rec. H 9427, 9526 (daily ed., Sept. 24, 2008), to the Department of Defense Appropriations Act Fiscal Year 2009, contained in Division C of the Consolidated Security, Disaster Assistance, and Continuing Appropriations Act, 2009, Pub. L. No. 110-329.

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performance of DOD's portfolio of 98 major defense acquisition programs, we obtained cost, schedule, and quantity data from DOD's Selected Acquisition Reports (SAR) and from the Defense Acquisition Management Information Retrieval Purview system.<sup>2</sup> For unit cost reporting, DOD breaks several of these 98 programs into components. Therefore, some of our analysis is based on 100 or 101 programs or components. To analyze factors that can affect program outcomes and to assess how well programs are adhering to a knowledge-based acquisition approach, we examined a subset of 40 major defense acquisition programs and components from DOD's 2010 portfolio that were in development or early production as of June 2010. We submitted a questionnaire to program offices to collect information on aspects of program management including performance requirements, manufacturing planning, software development, and program office staffing. All 40 major defense acquisition programs we surveyed that were in development or early production responded to our questionnaire. We also obtained information on the extent to which they follow knowledge-based practices for technology maturity, design stability, and production maturity using a data collection instrument provided to 40 programs. To examine the extent to which DOD is implementing recent acquisition reforms, we used additional information from a questionnaire submitted to 17 planned major defense acquisition programs approaching program start; 14 of these planned programs responded. In addition to our observations, we present one- or two-page assessments of 71 weapon programs. We chose these 71 programs based on their estimated cost, stage in the acquisition process, and congressional interest.

We conducted this performance audit from June 2010 to March 2011 in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings based on our audit objectives. Appendix I contains detailed information on our scope and methodology.

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<sup>2</sup>Major defense acquisition programs are those identified by DOD that require eventual total research, development, test, and evaluation (RDT&E) expenditures, including all planned increments, of more than \$365 million, or procurement expenditures, including all planned increments, of more than \$2.19 billion, in fiscal year 2000 constant dollars.

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## Observations on DOD's 2010 Major Defense Acquisition Program Portfolio

Since 2008, the number of programs in DOD's portfolio of major defense acquisition programs has increased from 96 to 98, and DOD's total planned investment in these programs has increased by \$45 billion to \$1.68 trillion.<sup>3</sup> Thirteen programs with a total estimated cost of \$174 billion left the portfolio.<sup>4</sup> Fifteen programs with an estimated cost of \$77 billion entered the portfolio.<sup>5</sup> These programs are smaller, on average, than those already in the portfolio. Our analysis of the 98 programs in DOD's 2010 portfolio of major defense acquisition programs allows us to make five observations about the overall portfolio, as well as about the performance of individual programs. First, the total cost of the programs in DOD's portfolio has grown by about \$135 billion, or 9 percent, over the last 2 years, of which about \$70 billion cannot be attributed to quantity changes. We focused on this 2-year period instead of program performance against initial estimates in order to assess the department's recent management of major defense acquisition programs.<sup>6</sup> Second, over half of the portfolio's total cost growth over the last 2 years is driven by 10 of DOD's largest programs, which are all in production. As these programs leave the portfolio through completion or cancellation, their cost will leave with them. Third, about half of the programs in the portfolio have experienced cost increases that exceed cost

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<sup>3</sup>All dollar figures are in fiscal year 2011 constant dollars unless otherwise noted.

<sup>4</sup>The 13 programs that have left the portfolio include the Advanced Deployable System (AN/WQR-3), Armed Reconnaissance Helicopter, Defense Integrated Military Human Resources System, Extended Range Munition, Future Combat System, Advanced Anti-Tank Weapon System-Medium (Javelin), Minuteman III Guidance Replacement Program, Mission Planning System, Small Diameter Bomb Increment 1, Ship Self Defense System, Ohio Class SSGN Conversion, T-45TS Naval Undergraduate Jet Flight Training System (Goshawk), and Presidential Helicopter Replacement (VH-71) Program.

<sup>5</sup>The 15 programs that have entered the portfolio include the Airborne Signals Intelligence Payload-Baseline, Army Integrated Air and Missile Defense, Broad Area Maritime Surveillance Unmanned Aircraft System, C-27J Joint Cargo Aircraft, EA-6B Improved Capability III, Gray Eagle Unmanned Aircraft System, Global Positioning System IIIA, Increment 1 Early-Infantry Brigade Combat Team, Integrated Defensive Electronic Countermeasures, Joint High Speed Vessel, Joint Precision Approach and Landing System, Airborne and Maritime/Fixed Station Joint Tactical Radio System, Predator Unmanned Aircraft System, Reaper Unmanned Aircraft System, and Warfighter Information Network-Tactical Increment 3. Not all of these programs are new starts. Several began as acquisition category II programs before growing in cost.

<sup>6</sup>We chose a 2-year period instead of a 1-year period because DOD did not issue annual, comprehensive Selected Acquisition Reports in December 2008.

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performance goals agreed to by DOD, OMB, and GAO.<sup>7</sup> Fourth, almost 80 percent of the programs in the portfolio have experienced an increase in unit cost when compared to their original estimates, thereby reducing DOD's buying power on these programs. Fifth, on average, the majority of cost growth materialized after programs entered production, meaning they continued to experience significant changes well after the programs and their costs should have stabilized. Additional details about each of these observations follow.

- **The total cost of DOD's 2010 portfolio of major defense acquisition programs has grown by \$135 billion, or 9 percent, over the past 2 years, of which about \$70 billion cannot be attributed to changes in quantities of some weapon systems.** As shown in table 1, since 2008, the total cost to develop and procure all of the weapon systems in this year's portfolio has increased by \$135 billion, or 9 percent.<sup>8</sup> About \$65 billion of that growth can be attributed to quantity changes on 57 programs.<sup>9</sup> The DDG 51 Destroyer, Joint Mine Resistant Ambush Protected vehicle, and C-17A aircraft programs experienced the largest cost increases due to increased quantities and account for almost half of that growth. The remaining \$70 billion in cost growth is not attributable to quantity changes. For example, the procurement cost of the Joint Strike Fighter program increased by \$28 billion in the last 2 years without a change in quantities. This type of cost growth could be indicative of production problems and inefficiencies or flawed initial cost estimates. Additionally, research and development costs increased by \$15 billion over the past 2 years. Five programs—the Joint Strike Fighter, CH-53K Heavy Lift Replacement, F-22 Raptor, Space Based Infrared System High, and Advanced Extremely High Frequency Satellite—accounted for 70 percent of this increase with each

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<sup>7</sup>DOD, OMB, and GAO agreed upon outcome metrics designed to evaluate program performance by measuring acquisition cost growth over the last year, the last 5 years, and since their original program estimate.

<sup>8</sup>App. II includes 5-year and baseline estimate comparisons for the overall 2010 portfolio.

<sup>9</sup>Programs that increased quantities had \$87 billion in cost growth attributable to those increased purchases and programs that reduced quantities had \$22 billion in cost decreases attributable to those reduced purchases. To calculate the portion of the procurement cost growth attributable to quantity changes, we compared a program's average procurement unit cost from December 2007 with its average procurement unit cost from December 2009. When quantities changed, we multiplied the change by the previous average procurement unit cost to determine the cost growth due to these quantity changes. See app. I for additional information on our scope and methodology.



experiencing research and development cost growth of over \$1 billion. With the exception of CH-53K, these programs are all in production, but are still incurring additional research and development costs. For the most part, these programs began with unrealistic business cases, which contributed to these poor outcomes.<sup>10</sup>

**Table 1: Changes in DOD's 2010 Portfolio of Major Defense Acquisition Programs over the Past 2 Years**

Fiscal year 2011 dollars in billions

	Estimated portfolio cost in 2008 <sup>a</sup>	Estimated portfolio cost in 2010	Estimated portfolio cost growth since 2008 <sup>b</sup>	Percentage growth since 2008 <sup>b</sup>
Total estimated research and development cost	\$407	\$428	\$15	5%
Total estimated procurement cost	1,089	1,219	121	11
Total estimated acquisition cost	1,531	1,680	135	9
Average delay in delivering initial capabilities	—	—	5 months	8

Source: GAO analysis of DOD data.

Notes: In addition to research and development and procurement costs, total acquisition cost includes acquisition operation and maintenance and system-specific military construction costs. Details on program costs used for this analysis are provided in app. III.

<sup>a</sup>The 2008 estimate includes costs for the 83 programs that are at least 2 years old, and the first available estimate for the remaining 15 programs that are new to the 2010 portfolio.

<sup>b</sup>The portfolio cost columns include the reported cost of the Ballistic Missile Defense System (BMDS); however, the portfolio cost growth columns do not include \$6 billion in research and development and \$9 billion in procurement cost changes for the BMDS. DOD does not consider these adjustments to represent cost growth because the program has been allowed to add 2 years of new funding with each biennial budget.

In addition to higher costs, programs in the 2010 portfolio have also experienced additional delays within the past 2 years. The average delay in delivering initial capabilities increased by 5 months. When examined from a longer-term perspective, the average delay in delivering initial capabilities is 22 months for these programs when measured against their first full estimates. See appendix II for our analysis of cost growth and delays in

<sup>10</sup>GAO, *Tactical Aircraft: Recapitalization Goals Are Not Supported by Knowledge-Based F-22A and JSF Business Cases*, [GAO-06-487T](#) (Washington, D.C.: Mar. 16, 2006); *Defense Acquisitions: Despite Restructuring, SBIRS High Program Remains at Risk of Cost and Schedule Overruns*, [GAO-04-48](#) (Washington, D.C.: Oct. 31, 2003); and *Defense Acquisitions: Space System Acquisition Risks and Keys to Addressing Them*, [GAO-06-776R](#) (Washington, D.C.: June 1, 2006).

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delivering initial capabilities against first full estimates for DOD's 2010 portfolio of major defense acquisition programs.

- **Ten of DOD's largest acquisition programs account for over half the portfolio's total acquisition cost growth over the past 2 years.** DOD's largest programs represent more than half of its total investment in major defense acquisition programs. These programs range in age from 3 to 32 years; all 10 are in production; and 8 have attained initial operational capability. Collectively, the estimated cost of these programs is \$853 billion. These 10 programs account for \$79 billion in cost growth over the last 2 years, or over half of the \$135 billion in total cost growth for this period. Of the \$79 billion in cost growth, \$35 billion is attributable to increased purchases—primarily of the C-17A aircraft, DDG 51 Destroyer, and Joint Mine Resistant Ambush Protected family of vehicles, which has been in high demand because of the conflicts in Iraq and Afghanistan. When examined from a more historical perspective, the total acquisition cost of these 10 programs has grown by \$196 billion over their first full estimates, which is almost half of the \$402 billion in total cost growth for the 2010 portfolio. As these programs leave the portfolio through completion or cancellation, their cost will leave with them. While some of these programs are nearing the end of their procurement, others such as the Joint Strike Fighter, Virginia Class Submarine, V-22, and CVN 21 will continue to demand large amounts of annual funding. Table 2 provides a summary of 10 of the largest DOD acquisition programs.

**Table 2: Changes in Total Acquisition Cost and Program Acquisition Unit Cost for 10 of the Highest-Cost Acquisition Programs**

Program	Total acquisition cost (fiscal year 2011 dollars in millions)			Program acquisition unit cost (fiscal year 2011 dollars in millions)		
	2008 estimate	2010 estimate	Change over the last 2 years	2008 estimate	2010 estimate	Percentage change over the last 2 years
Joint Strike Fighter	249,690	283,674	33,984	101.7	115.5	13.6
DDG 51 Destroyer	77,382	94,344	16,961	1,248.1	1,328.8	6.5
C-17A Globemaster III	75,046	82,347	7,301	395.0	369.3	-6.5
Virginia Class Submarine (SSN 774)	83,194	82,193	-1,002	2,773.1	2,739.8	-1.2
F-22 Raptor	75,200	77,393	2,193	408.7	411.7	0.7
V-22 Joint Services Advanced Vertical Lift Aircraft (Osprey)	56,659	56,061	-598	123.7	122.4	-1.1
F/A-18E/F Super Hornet	52,824	54,625	1,801	107.1	106.1	-1.0
Trident II Missile	50,611	51,410	799	90.2	91.6	1.6
Joint Mine Resistant Ambush Protected (MRAP)	22,792	36,375	13,583	1.5	1.6	7.2
CVN 21 Future Aircraft Carrier	30,513	34,186	3,673	10,171.0	11,395.2	12.0
<b>Total</b>	<b>773,911</b>	<b>852,607</b>	<b>78,696</b>	<b>—</b>	<b>—</b>	<b>—</b>

Source: GAO analysis of DOD data.

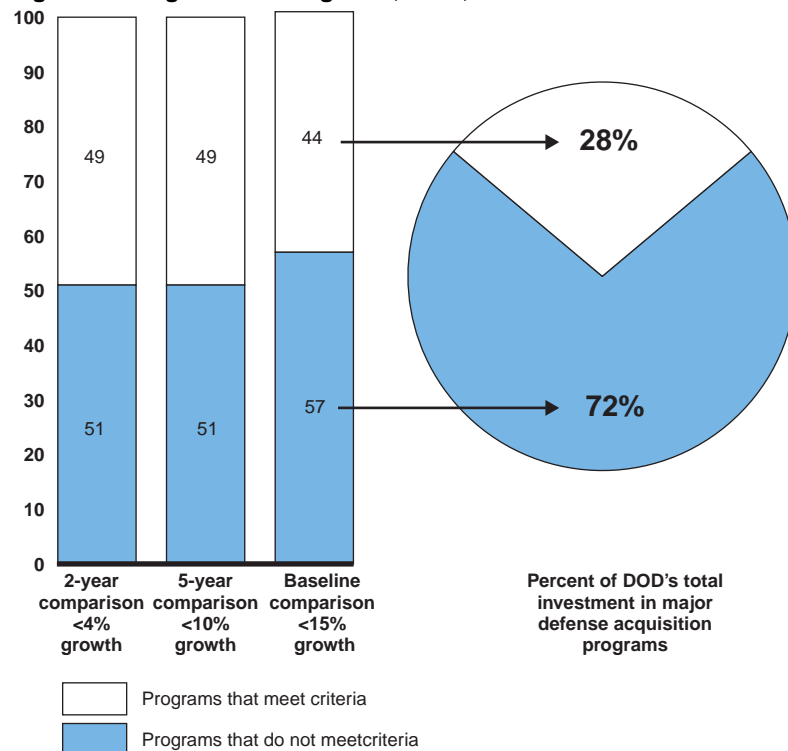
Note: Figures may not add due to rounding.

- Fewer than half of the programs in DOD’s 2010 portfolio are meeting established performance metrics for cost growth.** In December 2008, DOD, working with OMB and GAO, developed a set of outcome metrics and goals to measure program performance over time. As shown in figure 1, less than half of the programs in DOD’s 2010 portfolio met the total acquisition cost growth goals that were set.<sup>11</sup> The metrics also show that those programs experiencing significant cost growth—more than 15 percent over initial estimates—dominate DOD’s

<sup>11</sup>These metrics are designed to capture total cost growth performance over 1-year and 5-year periods and from the original program estimate. We modified these metrics to measure a 2-year comparison since cost data were not available to make a 1-year comparison.

portfolio, representing about 72 percent of DOD's total investment in its major defense acquisition programs.<sup>12</sup>

**Figure 1: Programs Meeting DOD, OMB, and GAO Cost Performance Metrics**



Source: GAO analysis of DOD data.

Notes: The number of programs represents those in the 2010 portfolio—those with December 2009 SARs—which break down several programs into smaller elements for reporting purposes. One program, Airborne Signals Intelligence Payload (ASIP)-Baseline, was not included in 2-year and 5-year comparisons because data were not available to make those comparisons.

- **DOD's buying power has been reduced for almost 80 percent of its portfolio of major defense acquisition programs.** Of the 100 programs or components in DOD's 2010 portfolio that reported program acquisition unit cost data, 79 are planning to deliver capabilities at

<sup>12</sup>The original estimates we used are primarily programs' cost estimates at development start. These may differ from DOD baseline estimates used for Nunn-McCurdy cost growth purposes, which can be reset after a Nunn-McCurdy unit cost breach of the critical threshold.

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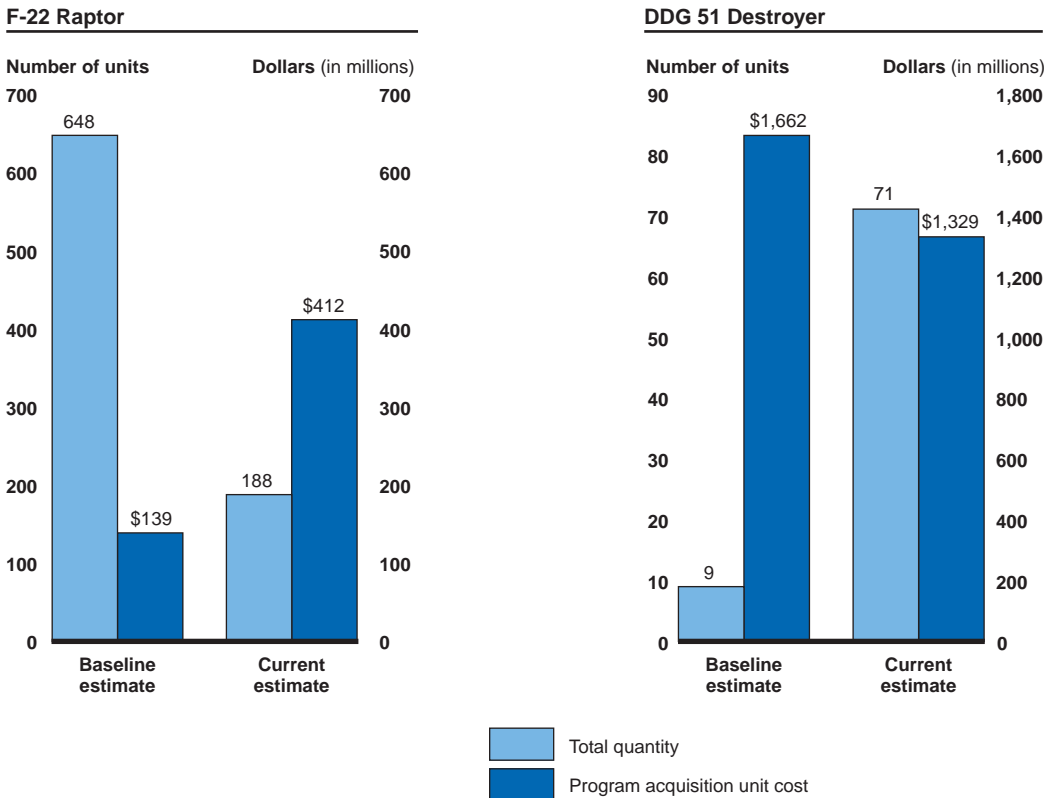
higher unit costs than originally estimated, while only 21 are planning to deliver capabilities at or below initial estimates.<sup>13</sup> We did not examine whether these programs delivered a lower or higher level of performance than initially promised. To quantify the change in DOD's buying power, we examined changes in program acquisition unit cost and quantities.<sup>14</sup> An example of a program that experienced reduced buying power is the F-22 Raptor. Despite a 70 percent reduction in quantities for the program, total acquisition costs have only decreased by 14 percent, due to research and development and average procurement unit cost increases. As a result, program acquisition unit costs for the F-22 Raptor have almost tripled, from \$139 million to \$412 million per airplane. For the current 188 aircraft program, the \$273 million increase per plane translates to \$51.3 billion in lost buying power for the F-22 program as a whole. Conversely, some programs are planning to deliver more quantities than planned at a lower program acquisition unit cost, which translates into increased buying power for DOD. For example, despite research and development costs almost tripling and the total program cost increasing by \$79 billion, the DDG 51 Destroyer's program acquisition unit cost has decreased by about 20 percent, because it has spread out those research and development costs over significantly higher quantities and its average procurement unit cost has decreased over time. For the currently planned fleet of 71 ships, the \$333 million reduction per ship corresponds to \$24 billion in increased buying power for the program as a whole.

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<sup>13</sup>Program acquisition unit cost is the total cost for development, procurement, acquisition operation and maintenance, and system-specific military construction for the acquisition program divided by the number of items to be produced. DOD's 2010 portfolio includes 98 programs with SARs; however, DOD's SAR summary tables break down several of these programs into smaller elements. We did not include the Missile Defense Agency's (MDA) Ballistic Missile Defense System because comparable cost and schedule data were not available, or the National Polar-orbiting Operational Environmental Satellite System, because quantities were reduced to zero.

<sup>14</sup>We calculated the effect on DOD's buying power from a program by multiplying the change in the program acquisition unit cost by the current planned quantities.

Figure 2: Change in Planned Quantities and Program Acquisition Unit Cost for the F-22 Raptor and DDG 51 Destroyer



Source: GAO analysis of DOD data.

- On average, the majority of cost growth materialized after programs entered production, meaning they continued to experience significant changes well after the programs and their costs should have stabilized. For the 56 major defense acquisition programs in DOD’s 2010 portfolio that had production cost estimates as of the end of 2009, we found that the average program experienced the majority of its research and development and procurement cost growth after its production decision. Fifty-two percent of the average program’s research and development cost growth was incurred after production start. Additionally, 65 percent of the average program’s procurement cost growth materialized after production start. On average, these programs are 14 years old. Given the age of the programs in this group, most of them were started before DOD acquisition policies were revised to promote a knowledge-based, evolutionary acquisition approach. Therefore, newer programs that follow a knowledge-based approach

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may be better positioned to avoid cost growth this late in the acquisition cycle.

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## Observations on Factors That Can Affect Program Outcomes

For 40 individual weapon programs in DOD's 2010 portfolio, we collected and assessed data on DOD's management of requirements, software, and program office staffing. We previously reported that both requirements changes and increases in the scope of software development were associated with poor program outcomes.<sup>15</sup> We found similar results this year. Our analysis of the data allows us to make three observations. First, over half of the programs in our assessment made a change to a key performance requirement after development start and experienced higher levels of cost growth and longer schedule delays than programs with unchanged requirements. Second, half of the programs in our assessment that provided data on software lines of code saw the scope of software development increase after development start, which also corresponded with poorer outcomes. Third, programs continue to use contractors to make up for staffing shortfalls, though programs' reliance on nongovernment personnel has declined from last year's assessment. Additional details about each of these observations follow.

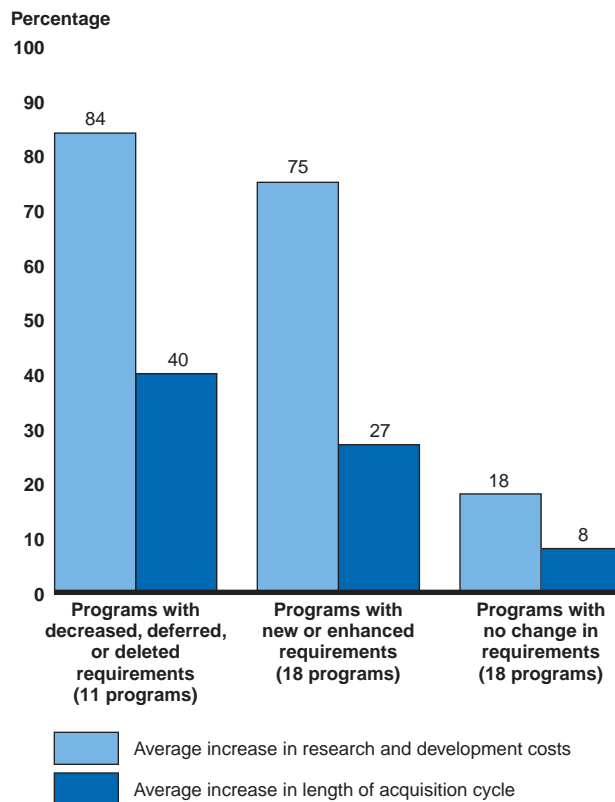
- **Programs that modified key performance requirements after development start experienced higher levels of cost growth and longer delays in delivering capabilities.** Of the 39 programs in our current assessment that reported tracking requirements changes since development start, 21 reported having had at least one change to a key performance parameter—a top-level requirement. Specifically, 10 of the 21 programs reported adding or enhancing a key performance parameter; 3 of the 21 programs reported reducing, deferring, or deleting a key performance parameter; and 8 of the 21 programs reported making both types of changes to key performance parameters. Most of the programs that experienced requirements changes are programs that started prior to 2005. While changing requirements creates instability and, therefore, can adversely affect program outcomes, it is also possible that some programs experiencing poor outcomes may be decreasing program requirements in an effort to prevent further cost growth. As shown in figure 3, programs with changes to performance requirements experienced roughly four times

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<sup>15</sup>GAO, *Defense Acquisitions: Assessments of Selected Weapon Programs*, [GAO-09-326SP](#) (Washington, D.C.: Mar. 30, 2009).

more growth in research and development costs and three to five times greater schedule delays compared to programs with unchanged requirements. Similarly, programs with increases to key system attributes—lower level, but still crucial requirements of the system—experienced greater, albeit less pronounced, cost growth and schedule delays than other programs.

**Figure 3: Relationship between Key Performance Parameter Changes, Research and Development Cost Growth, and Delays in Achieving Initial Operational Capabilities**



Source: GAO analysis of DOD data.

Notes: Programs that had both increases and decreases in key performance parameters are included in both categories. Cost and schedule data were not available for the Joint Air-to-Surface Standoff Missile Extended Range variant, which had a new or enhanced requirement.

- **Substantial increases in the scope of software development efforts after development start also correspond to higher cost growth and longer schedule delays.** In our last several assessments,



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we reported that programs experiencing more growth in software lines of code since development start had higher development cost growth and longer schedule delays than other programs. Similarly, for the 25 programs in our current assessment that reported data on lines of code, we found that increases in total lines of code after development start correlate highly with both increases in research and development costs and longer delays in achieving initial operational capability. Over half of these programs, or 14 of 25, estimated that the number of lines of code required for the system to function has grown or will grow by 25 percent or more. These programs tend to be those that began development more than 5 years ago. Newer programs have also experienced some software growth, though it has been less severe, on average. In addition to measuring growth in software lines of code, we have previously reported that collecting earned value management data for software development is a good management practice. Thirty-two of the 40 programs in our assessment reported collecting such data to help manage software development by allowing visibility into schedule and cost performance of software. These programs generally had software efforts that were more than twice as large, on average, as those programs that reported not collecting earned value data for software development. Finally, we have previously reported that tracking and capturing software defects in-phase is important because discovering defects out of phase can cause expensive rework later in programs. For the 21 programs that reported collecting some type of software defect data, on average, only 69 percent of the defects were corrected in the phase of software development in which they occurred.

- **Programs continue to use contractors to make up for staffing shortfalls, but reliance on nongovernment personnel has decreased.** Congress and DOD have made it a priority to ensure the acquisition workforce has the capacity, personnel, and skills needed to properly perform its mission. Most programs, however, continue to struggle to fill all staff positions authorized. Specifically, 36 of the 44 programs we surveyed reported having been authorized all the positions they requested, but a majority—23 programs—were unable to fill all of them.<sup>16</sup> A majority of programs we assessed reported that they are in the process of staffing unfilled positions. Several cited delays and difficulty in finding qualified candidates as reasons for not being able to fill these

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<sup>16</sup>In addition to data from 40 major defense acquisition programs, our analysis of program staffing includes data from four MDA elements.

positions. Additionally, almost all programs—39 of 44—reported using support contractors to make up for shortfalls in government personnel or capabilities.

Program offices’ reliance on contractors has decreased since last year’s assessment. As shown in table 3, more than half (55 percent) of all program office staff for the 44 programs in our assessment were government personnel—a reversal of the downward trend in the percentage of government personnel that we have reported in the previous 3 years.<sup>17</sup> The percentage of support contractors declined in every discipline. Support contractors still fill the majority of administrative support positions; however, the greatest numbers of support contractors continue to be in engineering and technical positions.

**Table 3: Program Office Composition for 44 DOD Programs, as of 2010**

Percentage of staff	Program management	Engineering	Contracting	Business functions	Administrative support	Other	Total
Military personnel	30	7	6	3	8	11	<b>10</b>
Civilian government	43	45	84	57	30	25	<b>46</b>
<b>Total government</b>	<b>73</b>	<b>52</b>	<b>90</b>	<b>60</b>	<b>37</b>	<b>36</b>	<b>55</b>
Support contractors	27	40	10	38	61	64	<b>39</b>
Other nongovernment <sup>a</sup>	0	8	0	2	2	0	<b>6</b>
<b>Total nongovernment</b>	<b>27</b>	<b>48</b>	<b>10</b>	<b>40</b>	<b>63</b>	<b>64</b>	<b>45</b>

Source: GAO analysis of DOD data.

Note: Totals may not add due to rounding.

<sup>a</sup>Other nongovernment includes federally funded research and development center and university-affiliated employees.

<sup>17</sup>We reported last year that 49 percent of program office staff were government personnel. The program offices we collected data from differ year to year. However, in both years, we focused on programs that were in development or the early stages of production.

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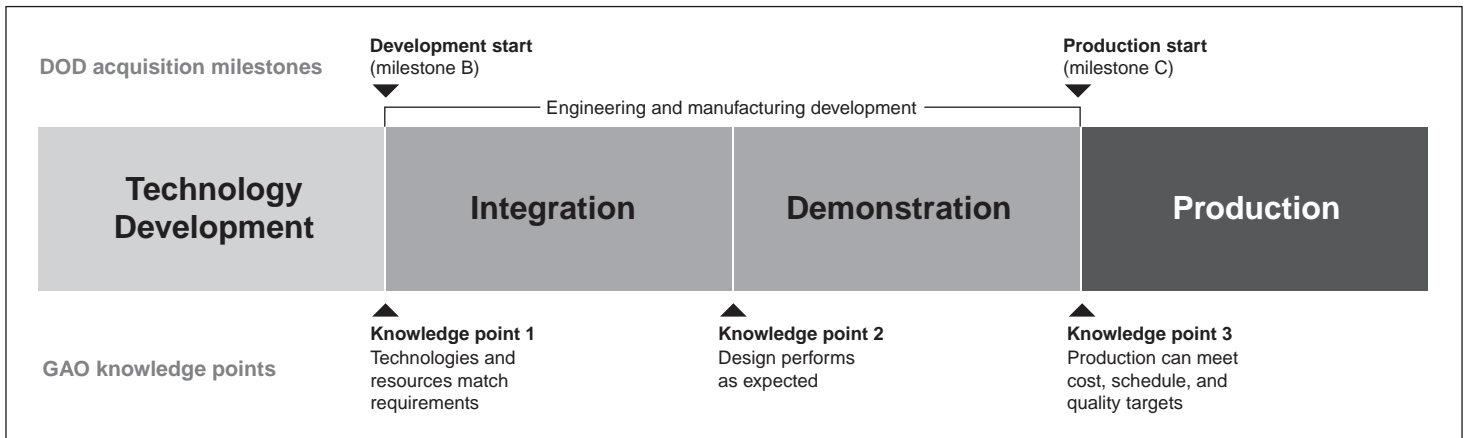
## Observations from Our Assessment of Knowledge Attained by Key Junctures in the Acquisition Process

Good acquisition outcomes require the use of a knowledge-based approach to product development that demonstrates high levels of knowledge before significant commitments are made. In essence, knowledge supplants risk over time. In our past work examining weapon acquisition issues and best practices for product development, we have found that leading commercial firms pursue an acquisition approach that is anchored in knowledge, whereby high levels of product knowledge are demonstrated by critical points in the acquisition process.<sup>18</sup> On the basis of this work, we have identified three key knowledge points during the acquisition cycle—development start; design review, which occurs during engineering and manufacturing development; and production start—at which programs need to demonstrate critical levels of knowledge to proceed. Figure 4 compares DOD acquisition milestones with the timing of the three knowledge points.

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<sup>18</sup>GAO, *Best Practices: Better Management of Technology Development Can Improve Weapon System Outcomes*, [GAO/NSIAD-99-162](#) (Washington, D.C.: July 30, 1999); *Best Practices: Better Matching of Needs and Resources Will Lead to Better Weapon System Outcomes*, [GAO-01-288](#) (Washington, D.C.: Mar. 8, 2001); *Best Practices: Capturing Design and Manufacturing Knowledge Early Improves Acquisition Outcomes*, [GAO-02-701](#) (Washington, D.C.: July 15, 2002); *Defense Acquisitions: A Knowledge-Based Funding Approach Could Improve Major Weapon System Program Outcomes*, [GAO-08-619](#) (Washington, D.C.: July 2, 2008); *Best Practices: High Levels of Knowledge at Key Points Differentiate Commercial Shipbuilding from Navy Shipbuilding*, [GAO-09-322](#) (Washington, D.C.: May 13, 2009); *Best Practices: DOD Can Achieve Better Outcomes by Standardizing the Way Manufacturing Risks Are Managed*, [GAO-10-439](#) (Washington, D.C.: Apr. 22, 2010).

Figure 4: DOD's Acquisition Cycle and GAO Knowledge Points



Source: GAO.

The building of knowledge consists of information that should be gathered at these three critical points over the course of a program:

- **Knowledge point 1: Resources and requirements match.** Achieving a high level of technology maturity by the start of system development is an important indicator of whether this match has been made. This means that the technologies needed to meet essential product requirements have been demonstrated to work in their intended environment. In addition, the developer has completed a preliminary design of the product that shows the design is feasible.
- **Knowledge point 2: Product design is stable.** This point occurs when a program determines that a product's design will meet customer requirements, as well as cost, schedule, and reliability targets. A best practice is to achieve design stability at the system-level critical design review, usually held midway through system development. Completion of at least 90 percent of engineering drawings at this point or 100 percent of the 3D product models for ships at fabrication start provides tangible evidence that the product's design is stable, and a prototype demonstration shows that the design is capable of meeting performance requirements.
- **Knowledge point 3: Manufacturing processes are mature.** This point is achieved when it has been demonstrated that the developer can manufacture the product within cost, schedule, and quality targets. A

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best practice is to ensure that all critical manufacturing processes are in statistical control—that is, they are repeatable, sustainable, and capable of consistently producing parts within the product’s quality tolerances and standards—at the start of production.

A knowledge-based acquisition approach is a cumulative process in which certain knowledge is acquired by key decision points before proceeding. In other words, demonstrating technology maturity is a prerequisite for moving forward into system development, during which the focus should be on design and integration. Additional details about key practices at each of the knowledge points can be found in appendix IV.

For 40 individual weapon programs in development and early production in DOD’s 2010 portfolio, we assessed the knowledge attained by key junctures in the acquisition process. In particular, we focused on the 17 programs that progressed through these key acquisition points since 2009 and evaluated their adherence to knowledge-based practices. While we continue to find that newer programs are demonstrating higher levels of knowledge at key decision points, most are still not fully adhering to a knowledge-based acquisition approach, putting them at a higher risk for cost growth and schedule delays.<sup>19</sup> Only one program in our assessment began system development since 2009, and it did so with all its critical technologies nearing maturity, in accordance with DOD and statutory requirements. However, it did not fully mature its critical technologies before beginning development, in accordance with knowledge-based practices, and only three nonship programs in our assessment had done so by development start. Six of nine programs that held a critical design review since 2009 did so with a stable design; however, these programs did not implement other practices that increase confidence that the design is stable and capable of meeting performance requirements. Finally, almost all programs that held a production decision since 2009 identified key product characteristics and critical manufacturing processes; however, none of the programs demonstrated that critical manufacturing processes were in control and only half tested production-representative prototypes prior to this decision. Additional details about these observations follow.

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<sup>19</sup>Not all programs provided information for every knowledge point or had reached all of the knowledge points—development start, design review, and production start. Because knowledge points differ for shipbuilding programs, we exclude them from our assessment of certain knowledge-based practices. App. IV contains a list of knowledge-based practices at each of the three knowledge points.

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- **The one program in our assessment that began development since 2009 did so with all its technologies nearing maturity, but few programs overall began development with fully mature technologies.** The Army's Integrated Air and Missile Defense (IAMD) program began development in 2009 with all critical technologies at least nearing maturity—that is, demonstrated in a relevant environment—in accordance with DOD and statutory requirements,<sup>20</sup> but did not demonstrate them in a realistic environment as GAO has recommended.<sup>21</sup> Our analysis of the 26 nonship programs in our assessment that provided technology data shows that only three of these programs began development with fully mature technologies—that is, demonstrated in a realistic environment. Our analysis also shows that mature technologies are associated with improved program outcomes. Specifically, the 3 programs that began development with fully mature technologies have experienced 4 percent less growth in research and development costs over their first estimates, on average, compared to the 11 programs that began development with all technologies at least nearing maturity, and 33 percent less growth, on average, than the 12 programs with at least one immature technology at the start of system development.

In addition, as shown in figure 5, the IAMD program did not implement other knowledge-based practices before beginning development, including holding a program-level preliminary design review and constraining the length of system development. We have previously reported that before starting development, programs should hold key system engineering events, such as the preliminary design review, to ensure that requirements are defined and feasible and that the proposed design can meet those requirements within cost, schedule, and other

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<sup>20</sup>According to DOD policy, in order to be considered mature enough to use in product development, technology shall have been demonstrated in a relevant environment or, preferably, in an operational environment. Department of Defense Instruction 5000.02, Operation of the Defense Acquisition System, enc. 2, para. 5.d.(4) (Dec. 8, 2008). In addition, a major defense acquisition program may not receive milestone B approval until the milestone decision authority certifies that the technology in the program has been demonstrated in a relevant environment. National Defense Authorization Act for Fiscal Year 2006, Pub. L. No. 109-163, § 801 (codified as amended at 10 U.S.C. § 2366b(a)(3)(D)).

<sup>21</sup>Demonstration in a relevant environment is Technology Readiness Level (TRL) 6. Demonstration in a realistic environment is TRL 7. See app. V for a detailed description of TRLs.

system constraints.<sup>22</sup> IAMD did hold a system requirements review and a system functional review before development start, which is a major improvement over other programs in our assessment, which held these reviews, on average, 18 months and 25 months after development start, respectively. Knowledge-based acquisition practices also recommend that a system or increment be developed in 5 to 6 years or fewer.<sup>23</sup> Further, DOD acquisition policy states that a condition for exiting technology development is that a system or increment can be developed for production within a short time frame, defined as normally less than 5 years for weapons systems. Constraining development time increases the predictability of funding needs and the likelihood of program success. While IAMD plans to follow an incremental approach, system development will take almost 7 years.

**Figure 5: Implementation of Knowledge-Based Practices by a Program Beginning Engineering and Manufacturing Development since 2009**

Knowledge-based practices at development start	IAMD
Knowledge point 1	
Mature all critical technologies	○
Hold system requirements review	●
Hold system functional review	●
Hold preliminary design review	○ <sup>a</sup>
Constrain development phase to 6 years or less	○

- Practice implemented by program
- Practice not implemented by program

Source: GAO analysis of DOD data.

<sup>a</sup>The IAMD program received a waiver for the requirement to hold a preliminary design review before beginning system development.

<sup>22</sup>GAO-09-326SP. A major defense acquisition program may not receive milestone B approval until the program has held a preliminary design review and the milestone decision authority has conducted a formal postpreliminary design review assessment and certified on the basis of such assessment that the program demonstrates a high likelihood of accomplishing its intended mission. Weapon Systems Acquisition Reform Act of 2009, Pub. L. No. 111-23, § 205(a)(3) (codified at 10 U.S.C. § 2366b(a)(2)). IAMD received a waiver from this requirement.

<sup>23</sup>GAO-08-619.

- Six of nine programs in our assessment that held a critical design review since 2009 did so with a stable design; however, these programs did not implement other knowledge-based practices to increase confidence that the design is stable.** Knowing a product's design is stable before system demonstration reduces the risk of costly design changes occurring during the manufacturing of production-representative prototypes—when investments in acquisitions become more significant. The overall design knowledge that programs have demonstrated at their critical design review has increased over the last few years, and six of nine programs that held a design review since 2009 did so with a stable design. However, as shown in figure 6, none of the nine programs in our assessment that held their critical design review since 2009 demonstrated that their design is capable of meeting performance requirements by testing an integrated prototype before the design review. We have previously reported that early system prototypes are useful to demonstrate design stability and that the design will work and can be built. On average, the nine programs tested or plan to test an integrated prototype 13 months after the critical design review, which is an improvement over the 31-month average we reported in last year's assessment.

**Figure 6: Implementation of Knowledge-Based Practices by Programs Holding Their Critical Design Review since 2009**

Knowledge-based practices at design review	AB3	AMF JTRS	CH-53K	FAB-T	GPS IIIA	Increment 1 E-IBCT	JPALS	PATRIOT/MEADS CAP Fire Unit	Reaper
Mature all critical technologies	○	○	○	○	●	○	○	●	●
Release at least 90 percent of design drawings	○	●	●	○	●	○	●	●	●
Test a system-level integrated prototype	○	○	○	○	○	○	○	○	
Use a reliability growth curve	○	○	○	○	○	●	●	●	○
Conduct producibility assessments to identify manufacturing risks for key technologies	●	●	●		●	●		●	
Complete failure modes and effects analysis	●	●	●	●	●	●		●	

● Practice implemented by program  
 ○ Practice not implemented by program  
 Practice not applicable or information not available

Source: GAO analysis of DOD data.



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Many of these programs are also still concurrently developing technologies and finalizing designs, which can lead to cost and schedule inefficiencies and rework. Of the nine programs, only three had fully matured all critical technologies at this point in the acquisition cycle. The remaining programs accepted technologies into their product's design based on no more than a laboratory demonstration of basic performance, technical feasibility, and functionality instead of a representative model or prototype in a realistic environment.

Despite not demonstrating that their design is stable, many of these programs are taking steps to plan for production. Almost all programs that held their critical design review since 2009 reported completing failure modes and effects analysis to identify potential failures and early design fixes and conducting producibility assessments to identify manufacturing risks for key technologies. However, only three programs reported having a reliability growth curve at the time of the critical design review. Reliability growth testing provides visibility over how reliability is improving and uncovers design problems so fixes can be incorporated before production begins. Our assessment of programs in development or early production that provided cost data shows that on average, programs using a reliability growth curve have experienced about one-third the research and development cost growth after development start than programs that have not used a reliability growth curve.

- **Almost all programs that held a production decision since 2009 took steps to plan for manufacturing; however, none of the programs demonstrated that critical manufacturing processes were in control, and only half tested production-representative prototypes prior to this decision.** Capturing critical manufacturing knowledge before entering production helps ensure that a weapon system will work as intended and can be manufactured efficiently to meet cost, schedule, and quality targets. Identifying key product characteristics and the associated critical manufacturing processes is a key initial step to ensuring production elements are stable and in control. As shown in figure 7, almost all of the programs in our assessment that made a production decision since 2009 reported conducting these activities before entering production. However, none of the 10 programs that made a production decision since 2009 demonstrated that their critical manufacturing processes were in

statistical control at production start.<sup>24</sup> Bringing processes under statistical control reduces variations in parts manufacturing, thus reducing the potential for defects, and is generally less costly than performing extensive inspection after a product is built.

**Figure 7: Implementation of Knowledge-Based Practices by Programs Holding Their Production Decision since 2009**

Knowledge-based practices at production decision Knowledge point 3	AB3	C-130 AMP	E-2D AHE	GPS IIIA	Gray Eagle	Increment 1 E-IBCT	NMT	P-8A	SM-6	WIN-T Increment 2
Mature all critical technologies	●	●	●	●	○	○	●	●	●	●
Release at least 90 percent of design drawings	●	●	●	■	●	○	■	●	○	■
Identify key product characteristics	●	●	○	■	●	●	●	●	●	●
Identify critical manufacturing processes	●	●	●	●	●	●	●	●	●	■
Demonstrate critical processes are in statistical control	○	○	○	○	○	○	○	○	○	■
Demonstrate critical processes on a pilot production line	●	●	●	○	●	●	●	●	●	■
Test a production-representative prototype	●	●	●	○	○	○	●	○	○	●

● Practice implemented by program  
 ○ Practice not implemented by program  
 ■ Practice not applicable or information not available

Source: GAO analysis of DOD data.

Several programs also began production without knowledge they ought to have gained much earlier in their acquisition process. One program—Increment 1 Early-Infantry Brigade Combat Team (E-IBCT)—entered production without mature technologies or a stable design. Another program—Gray Eagle Unmanned Aircraft System—also did not have

<sup>24</sup>DOD policy states that the knowledge required for a major defense acquisition program to proceed beyond low-rate initial production shall include demonstrated control of the manufacturing process and acceptable reliability, the collection of statistical process control data, and demonstrated control and capability of critical processes. Department of Defense Instruction 5000.02, Operation of the Defense Acquisition System, enc. 2, para. 7.c.(2) (Dec. 8, 2008). Since we focus on the low-rate production decision, we did not specifically assess compliance with this requirement.

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mature technologies by its production decision, while the Standard Missile-6 (SM-6) began production without completing its design. These programs are at risk of continued cost growth.

Additionally, many of these programs are still not testing production-representative prototypes before committing to production. We previously reported that production and postproduction costs are minimized when a fully integrated, capable prototype is demonstrated to show that the system will work as intended in a reliable manner. These benefits are maximized when tests are completed prior to a production decision, because making design changes after production begins can be both costly and inefficient. Moreover, DOD's December 2008 revision to its acquisition policy requires programs to test production-representative articles before entering production. Only 5 of the 10 programs that held a production decision since 2009 reported testing a production-representative prototype before their production decision. However, 11 of the 13 programs that are scheduled to hold their production decision after 2010 and provided data do plan to test a fully configured prototype before that decision.

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## Observations about DOD's Implementation of Recent Acquisition Reforms

Last year we reported that DOD had begun to incorporate recent acquisition reforms into the strategies of new programs. These reforms—in DOD's December 2008 revised acquisition policy, the Weapon Systems Acquisition Reform Act of 2009, and recent defense authorization acts—require programs to invest more time and resources at the beginning of the acquisition process refining concepts through early systems engineering and building prototypes before beginning system development, among other requirements. In addition, for ongoing programs, DOD policy and statute require establishment of annual configuration steering boards to review all program requirements changes as well as to make recommendations on proposed descoping options that could help maintain a program's cost and schedule targets. Our examination of the extent to which weapon systems are adhering to recent acquisition reforms indicates that many, but not all, programs are implementing these reforms.

Our assessment allows us to make five observations concerning DOD's progress in implementing legislative and policy reforms. First, almost all of the 14 planned major defense acquisition programs we reviewed intend to hold preliminary design reviews before beginning development, but fewer are taking other actions, such as developing prototypes, that could improve

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their chances of success.<sup>25</sup> Second, seven of these programs reported making major cost, schedule, or performance tradeoffs to-date, as required under a DOD and statutory requirement that programs make appropriate tradeoffs before beginning development. Third, six of the planned programs have acquisition strategies that include competition after the start of development. Fourth, of the 40 programs in our assessment that have begun development or are in the early stages of production, about one-third have not yet held a configuration steering board meeting, and only five programs reported presenting descoping options at this meeting. Finally, as part of DOD's effort to "do more without more," the Under Secretary of Defense for Acquisition, Technology and Logistics is beginning to implement a range of efficiency initiatives that focus on affordability, tradeoffs, and portfolio reviews, and are consistent with past GAO recommendations. Additional details about these observations follow.

- **Almost all of the planned major defense acquisition programs in our assessment intend to conduct a preliminary design review before development start, but fewer are taking other actions, such as developing prototypes, that could improve their chances of success.** Thirteen of the 14 planned major defense acquisition programs we reviewed intend to hold a preliminary design review,<sup>26</sup> and all 10 that provided dates for this review plan to hold it before milestone B—the beginning of system development—as required by the Weapon Systems Acquisition Reform Act of 2009. Nine of the 14 planned programs intend to develop prototypes of the proposed weapon system or a key system element before milestone B.<sup>27</sup> Programs can seek a waiver of the prototyping requirement, as provided by the policy. Holding a preliminary design review before beginning development can help ensure that program requirements are defined and feasible, but by not developing prototypes, some programs might be missing an

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<sup>25</sup>We refer to DOD's designated pre-major defense acquisition programs (pre-MDAPs) as planned programs throughout this report.

<sup>26</sup>The Common Vertical Lift Support Platform program does not plan to hold a preliminary design review because the program is planning to enter the acquisition cycle at production start.

<sup>27</sup>According to DOD acquisition policy, the technology development strategy for a major defense acquisition program shall provide for prototypes of the system or, if a system prototype is not feasible, for prototypes of critical subsystems before the program gets approval to enter development. Under Secretary of Defense, Acquisition, Technology and Logistics Directive-Type Memorandum (DTM) 09-027—Implementation of the Weapon Systems Acquisition Reform Act of 2009, attachment 1, para. 4 (Dec. 4, 2009).

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opportunity to further reduce technical risk, refine requirements, validate designs and cost estimates, and evaluate manufacturing processes.

Programs can also put themselves in a better position to succeed by implementing incremental acquisition strategies that limit the time in development and constrain requirements. Seven of the 14 planned programs in our assessment reported using DOD's preferred incremental, or evolutionary, acquisition approach, while the other 7 programs planned for a single-step-to-full-capability. The single-step-to-full-capability approach affords few, if any, opportunities to incrementally, and thus more quickly and inexpensively, adapt the final system to the changing needs of the warfighter. Conversely, an evolutionary acquisition strategy emphasizes a more flexible approach that can help reduce risk because it delivers the weapon system in more manageable increments. In addition, six of the nine planned programs in our assessment that provided data plan to deliver capabilities in less than 6 years, the recommended time limit for system development, while the remaining three programs are planning for longer development periods. We have previously reported that constraining development cycles increases the predictability of funding needs and the likelihood of program success, while unconstrained and lengthy cycle times lead to higher costs and diminished military effectiveness.

- **Half of the planned programs we reviewed reported making major cost, schedule, or performance tradeoffs before beginning development.** DOD acquisition policy and statute require that the Milestone Decision Authority certify, before a program begins development, that appropriate tradeoffs among cost, schedule, and performance objectives have been made to ensure that the program is affordable. Seven of the 14 planned programs in our assessment reported making major cost, schedule, or performance tradeoffs during the technology development phase to-date. For example, in an effort to reduce cost, the Mobile Landing Platform program reduced requirements for size, personnel accommodations, and cargo fuel. The Joint Requirements Oversight Council is also statutorily required to consider cost, schedule, and performance tradeoffs when validating joint military requirements.
- **Fewer than half of planned programs have acquisition strategies to ensure competition throughout the acquisition cycle.** The

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Weapon Systems Acquisition Reform Act of 2009 requires that DOD ensure that the acquisition strategy for each major defense acquisition program includes measures to ensure competition, or the option of competition, throughout the program's life cycle. These measures may include developing competitive prototypes, dual-source contracting, and periodic competitions for subsystem upgrades. Incorporating competition throughout a program's life cycle can be used to drive productivity and thereby reduce program costs. Six of the 14 planned programs in our assessment reported having acquisition strategies that call for competition post-milestone B at the system or subsystem level.

- **About one-third of the major weapon programs in our assessment reported that a configuration steering board meeting has not been held for the program, and few program managers presented descoping options.** Under DOD's revised acquisition policy and in statute, ongoing programs are required to conduct annual configuration steering boards to review requirements changes and significant technical configuration changes that have the potential to result in cost and schedule effects on the program. Since January 2009, 10 programs in our assessment reported changing either a key performance parameter or key system attribute, but only 4 of these reported holding a configuration steering board meeting during that period. In addition, as of June 2010, 12 of the 40 programs in our assessment reported never having held a configuration steering board. In addition to conducting an annual board meeting, the program manager is expected to present descoping options that could reduce program costs or moderate requirements. Only five programs in our assessment reported having presented descoping options and four programs had their options approved.
- **The Under Secretary of Defense for Acquisition, Technology and Logistics is beginning to implement a range of efficiency initiatives that focus on affordability, tradeoffs, and portfolio reviews, and are consistent with past GAO recommendations.** In September 2010, the Under Secretary issued a memorandum intent on obtaining greater efficiency and productivity in defense spending. Several of the proposed initiatives build on the recent acquisition reforms that DOD has already begun to implement. For example, the memorandum emphasizes the need to set shorter program timelines and manage to them to avoid costly delays in delivering capability to the warfighter. To target affordability, the memo directs program managers to treat affordability as a requirement before programs are started. In

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addition, the memo underscores the policy and statutory requirement for making tradeoffs among cost, schedule, and performance objectives using systems engineering analysis prior to system development. To ensure competition throughout a program's life cycle, the memo proposes requiring the presentation of a competitive strategy at each program milestone. Finally, the Under Secretary proposed conducting portfolio analyses to eliminate redundancies across programs, providing the potential for substantial savings.

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## Assessments of Individual Programs

This section contains assessments of individual weapon programs. Each assessment presents data on the extent to which programs are following a knowledge-based approach to system development and other program information. In total, we present information on 71 weapon programs. For 49 programs, we produced two-page assessments discussing technology, design, and manufacturing knowledge obtained, as well as other program issues. Each two-page assessment also contains a comparison of total acquisition cost from the first full estimate for the program to the current estimate. The first full estimate is generally the cost estimate established at development start; however, for a few programs that did not have such an estimate, we used the estimate at production start instead. For shipbuilding programs, we used their planning estimates if those estimates were available. For programs that began as non-major defense acquisition programs, we used the first full estimate available. Forty-one of these 49 two-page assessments are of major defense acquisition programs, most of which are in development or early production; 3 assessments are of components of major defense acquisition programs, including elements of MDA's Ballistic Missile Defense System; and 5 assessments are of programs that were projected to become major defense acquisition programs during or soon after our review. In addition, we produced one-page assessments on the current status of 22 programs, which include 13 pre-major defense acquisition programs, 4 major defense acquisition programs that are past their full-rate production decision, 2 elements of MDA's Ballistic Missile Defense System, 1 major defense acquisition program that was recently terminated, 1 major defense acquisition program that is a commercially derived aircraft, and 1 technology demonstration program.

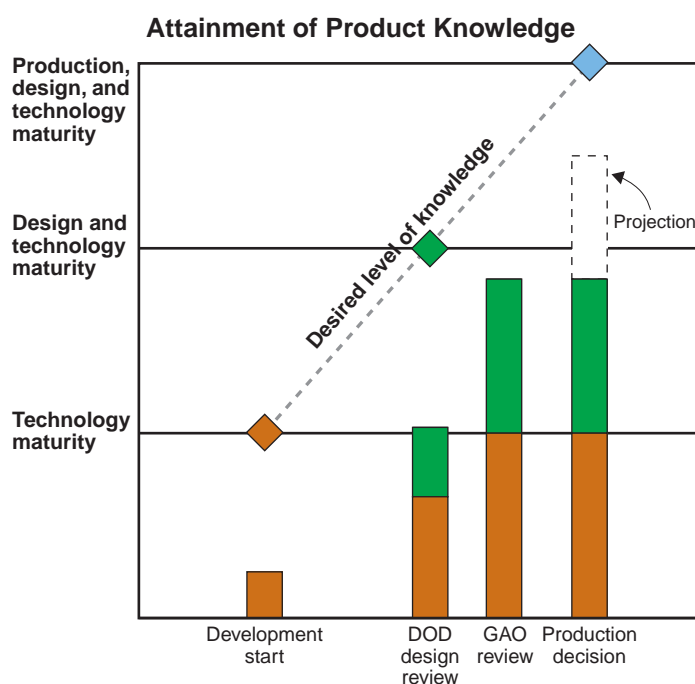
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## How to Read the Knowledge Graphic for Each Program Assessed

For our two-page assessments, we depict the extent of knowledge gained by key points in a program using a stacked bar graph and provide a narrative summary at the bottom of the first page of each assessment. As

illustrated in figure 8, the knowledge graph is based on three knowledge points. The key indicators for the attainment of knowledge are technology maturity (in orange), design stability (in green), and production maturity (in blue). A “best practice” line is drawn based on the ideal attainment of the three types of knowledge at the three knowledge points. The closer a program’s attained knowledge is to the best practice line, the more likely the weapon will be delivered within estimated cost and schedule. A knowledge deficit at development start—indicated by a gap between the technology maturity attained and the best practice line—means the program proceeded with immature technologies and faces a greater likelihood of cost and schedule increases as risks are discovered and resolved.

**Figure 8: Depiction of Notional Weapon System Knowledge as Compared with Knowledge-Based Practices**



Source: GAO.

An interpretation of this notional example would be that system development began with critical technologies that were partially immature, thereby missing knowledge point 1, which is indicated by the orange



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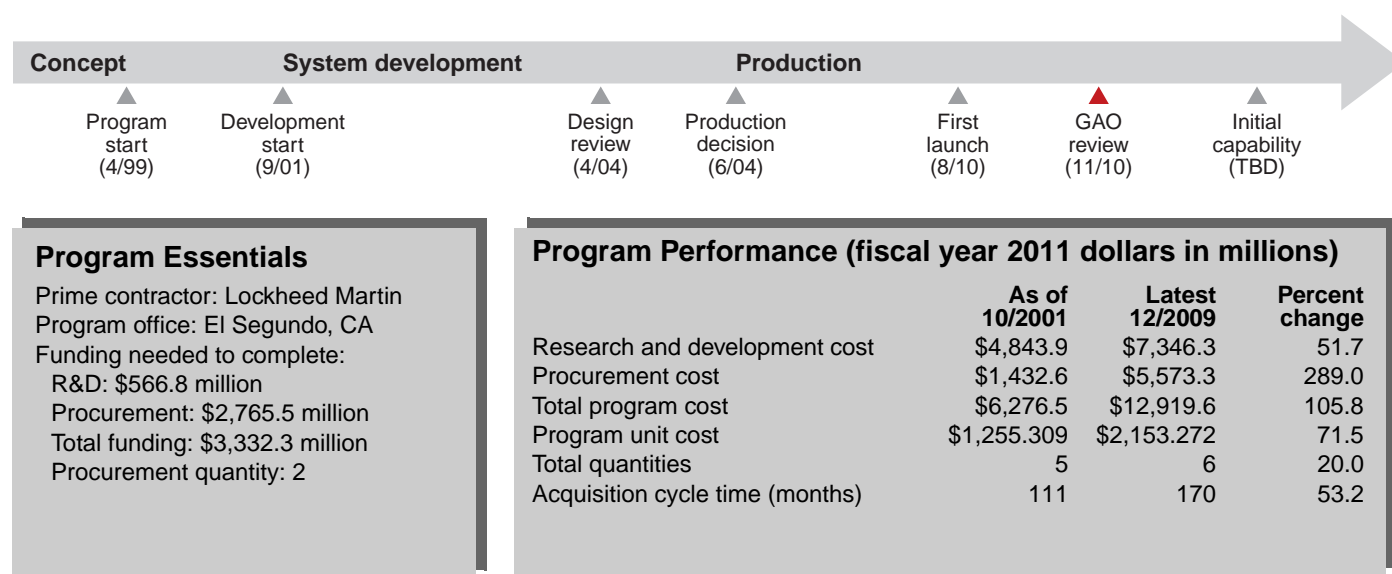
diamond. By the design review, technology knowledge had increased, as indicated by the orange bar, but all critical technologies were not yet mature; only 33 percent of the program's design drawings were releasable to the manufacturer, as indicated by the green bar. Therefore, knowledge point 2, which is indicated by the green diamond, was not attained. At the time of GAO's review, this program had matured all of its critical technologies and released approximately 75 percent of its design drawings, as indicated by the green bar. When the program plans to make a production decision, it expects to have released all of its design drawings and have half of its critical manufacturing processes in statistical control. The expected knowledge at this future point is captured in the outlined region marked "projection." This program is not projected to reach knowledge point 3, which is indicated by the blue diamond, by the time it makes a production decision. For shipbuilding programs, knowledge point 1 occurs when a program awards a detailed design and construction contract, and knowledge point 2 occurs when the lead ship starts fabrication. We do not assess production maturity at knowledge point 3 for shipbuilding programs.

## Advanced Extremely High Frequency (AEHF) Satellite

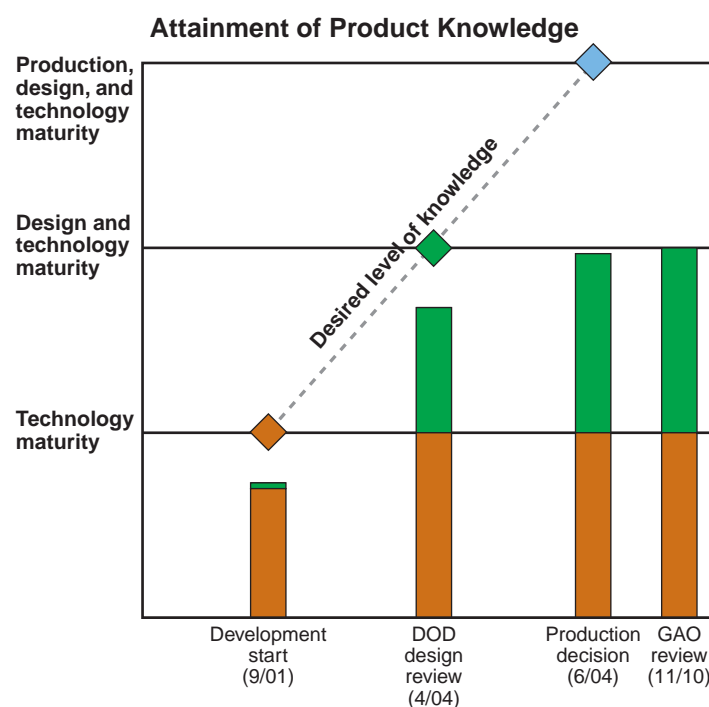
The Air Force's AEHF satellite system will replenish the existing Milstar system with higher-capacity, survivable, jam-resistant, worldwide, secure communication capabilities for strategic and tactical warfighters. The program includes satellites and a mission control segment. Terminals used to transmit and receive communications are acquired separately by each service. AEHF is an international program that includes Canada, the United Kingdom, and the Netherlands. We assessed the satellite and mission control segments.



Source: © 2009 Lockheed Martin Corporation. All rights reserved.



The first AEHF satellite (AEHF-1) was launched in August 2010; however, an anomaly with the satellite's propulsion system will delay the satellite from reaching its planned orbit and will affect the launch dates of the two satellites currently in testing. According to the program office, all 14 AEHF critical technologies are mature and its design is stable. However, the program is investigating the cause of the propulsion failure. We have not assessed the AEHF's production maturity because the program office does not collect statistical process control data. The Air Force plans to acquire six AEHF satellites that are expected to be clones except for changes to address obsolete parts, and is evaluating requirements and alternatives for meeting future military satellite communication needs beyond the sixth satellite.



## **AEHF Program**

### **Technology, Design, and Production Maturity**

According to the program office, all 14 AEHF critical technologies are mature and its design is stable with all of its expected design drawings released.

However, the program office is investigating the cause of a propulsion system failure on the first launched satellite. The propulsion system was not a critical technology and did not experience problems during prelaunch testing. We did not assess the AEHF's production maturity because the program office does not collect statistical process control data.

### **Other Program Issues**

AEHF-1 was launched in August 2010 on an Atlas V rocket; however, an anomaly with the propulsion system will delay the satellite from reaching its planned orbit and will affect the launch dates of the two satellites currently in testing. According to Air Force officials, the satellite separated from the rocket, as planned, and was expected to reach its intended orbit in about 3 months using its liquid apogee engine and hall current thrusters. The satellite's software aborted the liquid apogee engine burns due to low acceleration of the spacecraft, and this engine was rendered unusable because of the propulsion system anomaly. The Air Force plans to use the propulsion systems designed for controlling and repositioning the satellite to raise the satellite into its planned orbit. As a result, the satellite arrival on orbit will be delayed by about 7 to 9 months.

Once the satellite is in its designated orbit, the program office will conduct about 100 days of satellite checkout and system testing before the satellite becomes available for operations. The planned February 2011 launch of AEHF-2 was intended to provide enough time between launches to allow the first satellite to reach orbit and complete on-orbit checkout so any problems identified could be corrected in AEHF-2. Following the same model, the program office will delay the AEHF-2 launch until (1) it is cleared for flight in light of the AEHF-1 propulsion system anomaly and (2) AEHF-1 is on orbit and tested. AEHF-3 will launch about 8 months after AEHF-2. The program's initial operational capability, which requires two on-orbit satellites to achieve, will be delayed as well. The program office plans to complete a review to identify the root cause of the propulsion system

anomaly by the end of 2010. After that, the program office will determine what actions are required to clear AEHF-2 and AEHF-3 for launch.

The Air Force plans to procure three additional AEHF satellites—for a total of six—which will be clones of the first three except for obsolete parts. There will be an approximately 4-year break in production between the third and fourth satellites. The program office is working to resolve several obsolescence issues and has identified between 12 and 15 flight boxes that have parts that are no longer available from the original manufacturer. Program officials do not anticipate encountering significant technical challenges, but integrating, testing and requalifying the new parts will require additional time and money. The notional launch dates for satellites four through six are 2017, 2018, and 2020, respectively. The Air Force is in the process of developing a new acquisition program baseline that includes these satellites.

With the cancellation of the Transformational Satellite Communications System (TSAT) program in April 2009, the Air Force is in the process of reevaluating its military satellite communications requirements beyond the sixth AEHF satellite. It plans to conduct an analysis of alternatives to assess options for meeting future requirements, including the possible use of commercial satellite communications.

### **Program Office Comments**

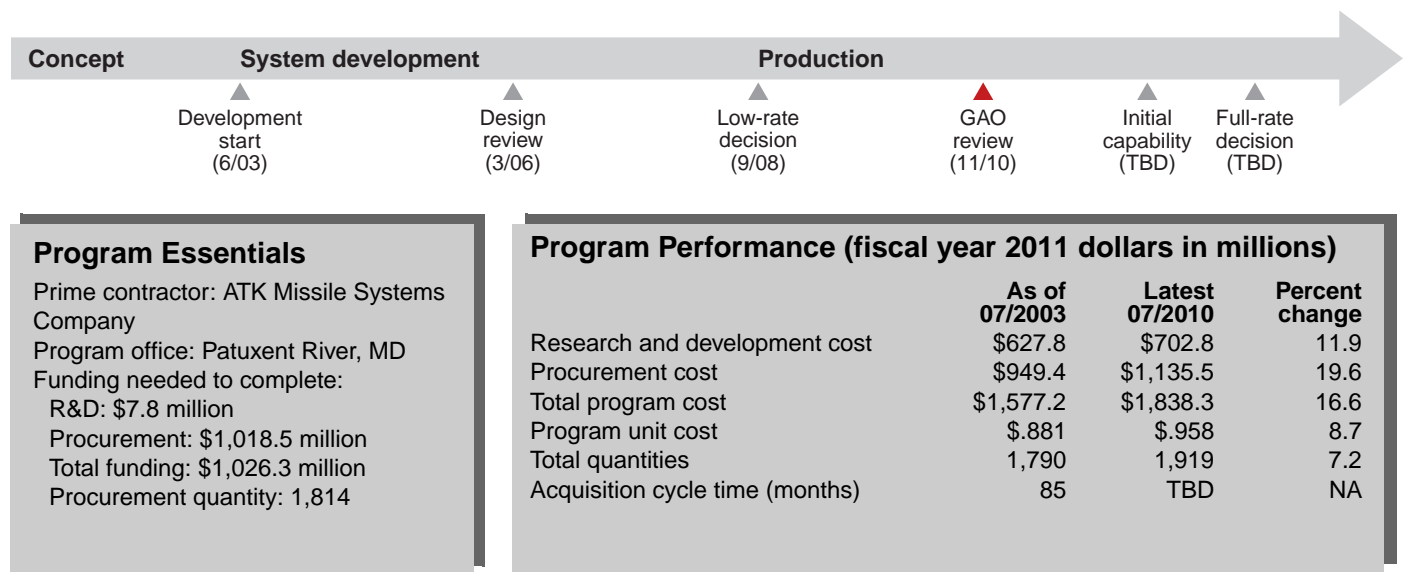
The AEHF program office provided technical comments, which were incorporated as appropriate.

## AGM-88E Advanced Anti-Radiation Guided Missile (AARGM)

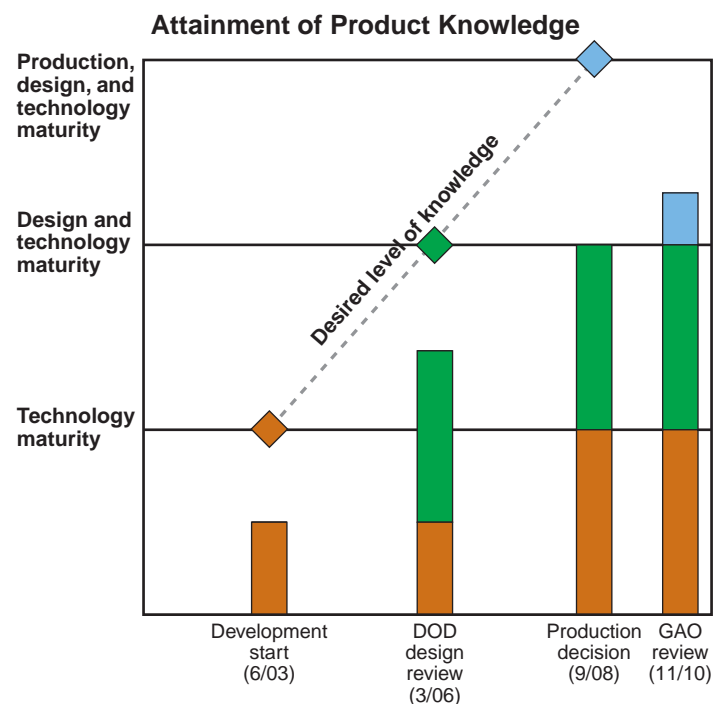
The Navy's AARGM is an air-to-ground-missile for carrier-based aircraft designed to destroy enemy radio-frequency-enabled surface-to-air defenses. The AARGM is an upgrade to the AGM-88 High Speed Anti-Radiation Missile (HARM). It will utilize the existing HARM propulsion and warhead sections, a modified control section, and a new guidance section with Global Positioning System and improved targeting capabilities. The program is following a phased approach for development. We assessed Phase I.



Source: U.S. Navy.



The AARGM program entered production in September 2008 with its critical technologies mature and design stable, but without demonstrating production maturity. Since then, the program has experienced multiple test delays, which could affect the program's planned delivery of initial operational capability in May 2011. The program began operational testing in June 2010 after a 9-month delay due to deficiencies in the missile's reliability and situational awareness and concerns about the production-representativeness of test missiles. The Navy halted operational testing in September 2010 after hardware and software issues caused a series of missile failures. According to Defense Contract Management Agency officials, the program is working with the contractor to identify the cause of the failures and develop corrective action plans.



## **AARGM Program**

### **Technology Maturity**

The AARGM program began system development in 2003 with its two critical technologies—the millimeter wave software and radome—nearing maturity. According to the program office, these technologies were mature and demonstrated in a realistic environment when the program entered production in September 2008. However, during development tests, the program identified deficiencies related to the missile's reliability and situational awareness that delayed the start of operational testing. As a result of these deficiencies, the program requested and received approval to defer demonstration of its lethality requirement for a specific target in a specified scenario until follow-on operational testing and evaluation. The Director, Operational Test and Evaluation (DOT&E), noted in its fiscal year 2009 assessment that software development challenges, including those related to the millimeter wave, continue to pose a risk to the program's schedule and the missile's reliability.

### **Design Maturity**

The design of the AARGM appears stable and all drawings were releasable to manufacturing by the start of production.

### **Production Maturity**

The AARGM program's production processes were not mature when it entered production in September 2008. According to the program office, the contractor identified 18 critical manufacturing processes, of which 5 are currently in statistical control. The program plans to demonstrate that all 18 processes are mature during the second lot of low-rate initial production. Since entering production, the program has experienced multiple production delays and operational test failures. According to Defense Contract Management Agency (DCMA) and DOT&E officials, the test failures were caused by both hardware and software issues. The hardware failures involved multiple subcontractors and were primarily attributed to poor parts quality. DCMA officials said that the contractor is conducting detailed supplier assessments to determine the cause of the failures and formulate corrective action plans. According to DOD's manufacturing readiness level deskbook, assessments of critical suppliers should be performed before a program enters production. Due

to the operational test failures, the program halted missile deliveries. According to DCMA officials, the program will return all delivered production missiles and production-representative test rounds to the contractor to implement any corrective actions. Prior to the test failures, the AARGM program office had already been working with the contractor to improve manufacturing planning, risk identification, and reporting. It also included a requirement for the contractor to develop a detailed manufacturing plan in the second low-rate production contract, awarded in July 2010.

### **Other Program Issues**

The AARGM program has experienced multiple test delays, which could affect the program's planned delivery of initial operational capability in May 2011. The program began operational testing in June 2010 after a 9-month delay due in part to concerns from DOT&E about the production-representativeness of test missiles. The Navy halted operational testing in September 2010 after hardware and software issues caused a series of missile failures. According to DOT&E, the program plans to conduct additional developmental tests and a new operational test readiness review in April 2011 before restarting operational tests.

### **Program Office Comments**

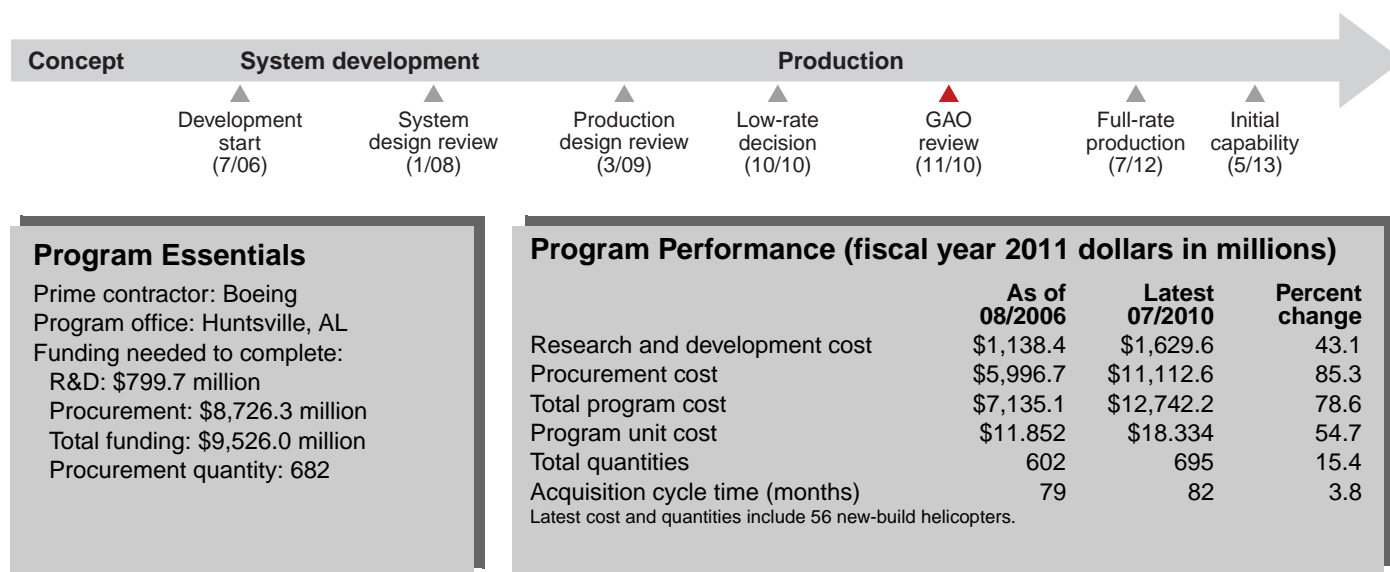
In commenting on a draft of this assessment, the Navy stated that the Program Executive Office, with the support of the Office of the Director of Air Warfare and the Commander, Operational Test and Evaluation Force, decertified AARGM from operational testing as a result of intermittent weapon failures and inaccurate weapon health reporting to the aircrew. Upon decertification, the program established a review team to assist in root cause analysis and system-level assessments. The team found immature manufacturing processes and software coding errors. A software development and test program is underway and has demonstrated improved performance. Manufacturing processes are being updated. The first rescreened missiles will enter flight testing by December 2010. An integrated test phase has been coordinated with DOT&E and the Commander, Operational Test and Evaluation Force, to reduce risk upon reentering operational test. The Italian Air Force remains committed to the program. Italian missile deliveries begin in 2011. The Navy also provided technical comments, which were incorporated as appropriate.

## Apache Block III (AB3)

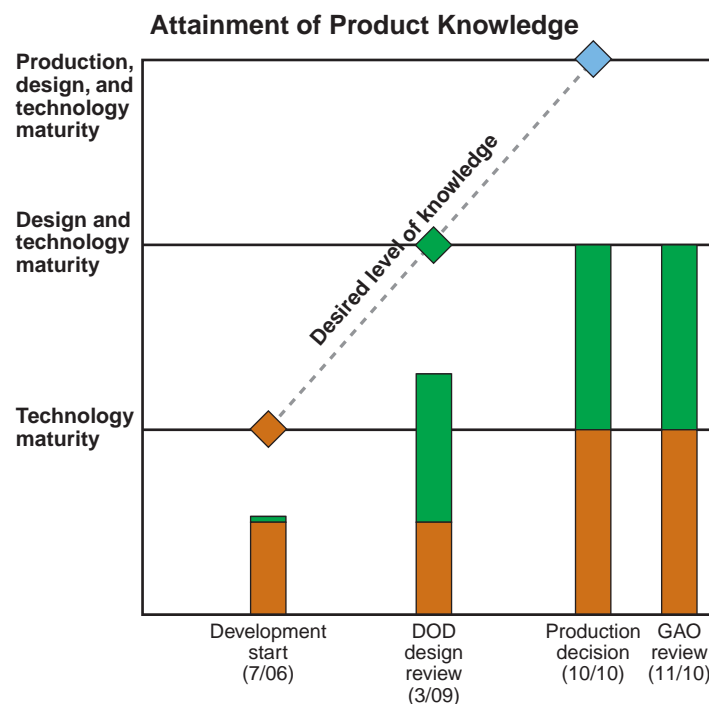
The Army's Apache Block III (AB3) program will upgrade AH-64D Longbow Apache helicopters. It is expected to improve performance, situational awareness, lethality, survivability, interoperability, and the prevention of friendly fire incidents. Each Apache goes to the factory for hardware changes. Software improvements can be installed in the field, which reduces the time an aircraft is away from the unit and increases the training time for soldiers in the field. Upgraded AH-64Ds are scheduled to enter service starting in 2011.



Source: U.S. Army.



In October 2010, the AB3 received approval to enter production with mature critical technologies and a stable hardware design. AB3 upgrades involve a time-phased series of hardware and software-related technical insertions. According to program officials, the design reviews for the hardware portion of the program have been held, all the expected design drawings are releaseable to manufacturing, and the last two software-related design reviews are scheduled for fiscal years 2012 and 2014. In May 2010, the Director, Defense Research and Engineering, assessed the AB3 as ready for production using engineering manufacturing readiness levels, a metric that includes technology and design maturity and production readiness. The AB3 program experienced a Nunn-McCurdy unit cost breach of the critical threshold in June 2010, due to the addition of 56 new-build helicopters to the upgrade program.



## **AB3 Program**

### **Technology Maturity**

The AB3 program's one critical technology—an improved drive system—is mature. This is the first time this technology will be used in a helicopter transmission, and it is expected to provide more power and be more reliable than the existing transmission. A developmental test aircraft has successfully completed flight tests and has demonstrated the maturity of the drive system in a realistic environment.

### **Design Maturity**

The AB3 hardware design is stable. AB3 upgrades involve a time-phased series of hardware and software-related technical insertions. The design reviews for the hardware portion of the program have been held and all the expected design drawings are releasable to manufacturing. According to program officials, the last two critical design reviews, which are software-related, should not significantly affect the total number of design drawings. These reviews are scheduled for fiscal years 2012 and 2014—after upgraded AH-64Ds are scheduled to start to enter service. According to program officials, the AB3 program uses a contract provision requiring the completion of 85 to 90 percent of the estimated design drawings for each design review as a mechanism for ensuring design stability. In addition, the success of each design review determines whether the program will move forward.

### **Production Maturity**

In October 2010, AB3 received approval to enter production. We did not assess production maturity because the program has not started to collect statistical process control data. However, the Director, Defense Research and Engineering, assessed the AB3 as ready for production in May 2010. The assessment used engineering manufacturing readiness levels, a metric that includes technology and design maturity and production readiness, as the basis for reaching this conclusion.

### **Other Program Issues**

The AB3 program experienced a Nunn-McCurdy unit cost breach of the critical threshold in June 2010 due to the addition of new-build helicopters to the upgrade program. The original AB3 program

involved taking legacy aircraft and remanufacturing them with upgraded capabilities. However, decreases in the numbers of legacy aircraft available for remanufacture due to combat losses, combined with increasing wartime demands and the addition of a 13th Combat Aviation Brigade, has resulted in a new acquisition strategy that includes acquiring 56 new-build aircraft. Since new-build Apaches cost three times more than a remanufactured Apache, a cost breach occurred. As part of its Nunn-McCurdy restructuring, the AB3 will be divided into two separate major defense acquisition programs—one for remanufactured aircraft and one for new builds. This division will permit visibility into the cost, schedule, and performance of both programs. Even after the program restructuring, risks remain in the AB3 program. An analysis by DOD's Program Assessment and Root Cause Analyses office noted that even though the AB3 contractor has performed well on its development contract, increasing software content, extensions of the development schedule, and the ability of the contractor to provide production aircraft at prices consistent with the existing program baseline, all pose risks for the current program.

### **Program Office Comments**

In commenting on a draft of this assessment, the Army provided technical comments, which were incorporated where appropriate.

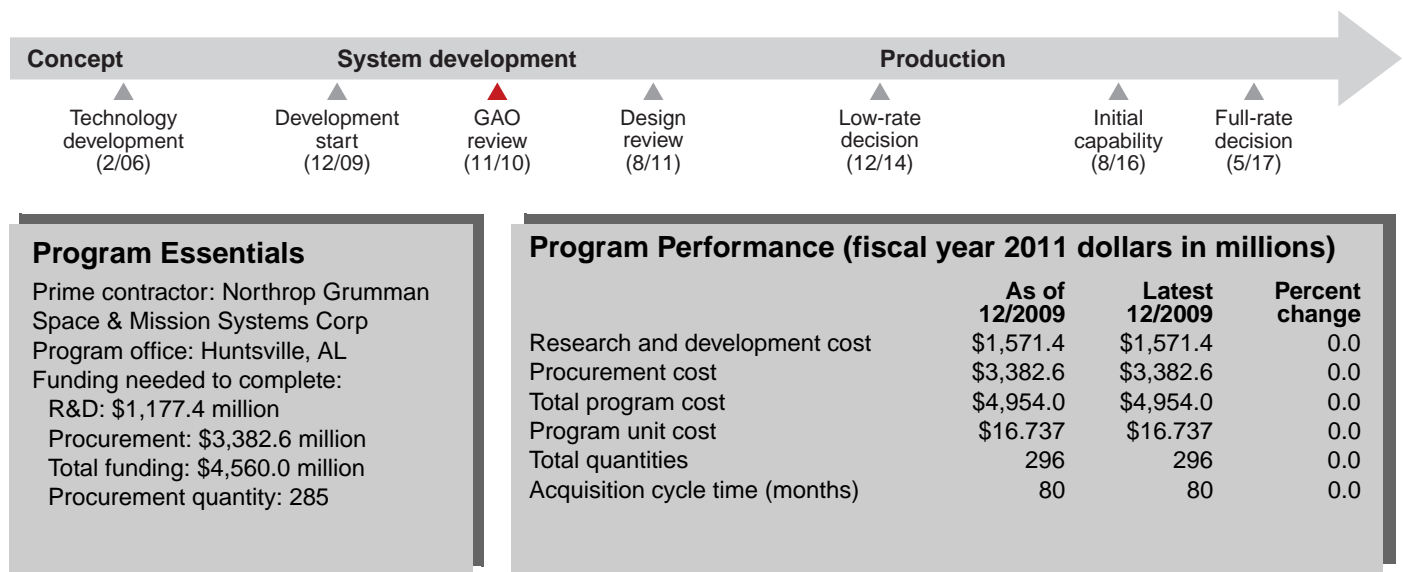


## Army Integrated Air and Missile Defense (Army IAMD)

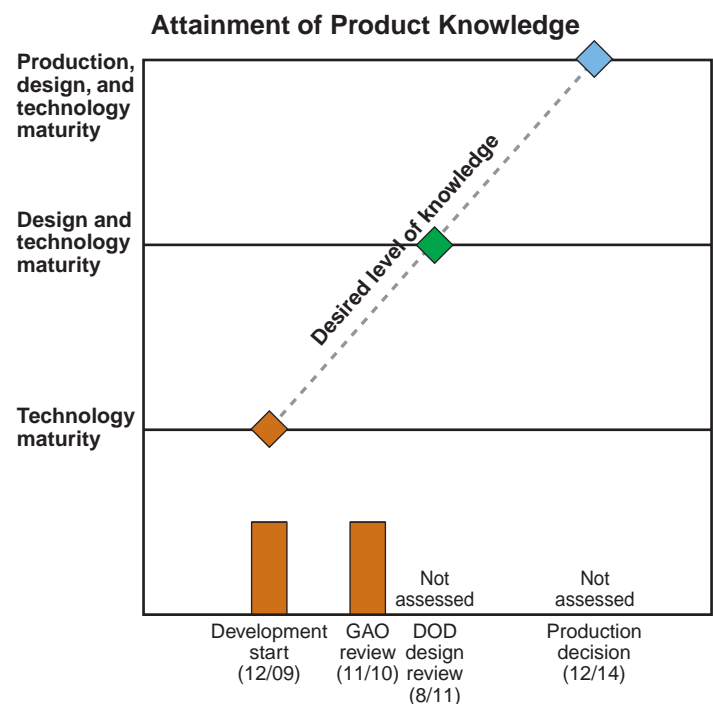
The Army's Integrated Air and Missile Defense (IAMD) program is being developed to network sensors and weapons and a common battle command system across a single integrated fire control network to support the engagement of air and missile threats. The IAMD Battle Command System (IBCS) will provide control and management for IAMD sensors and weapons, such as the Joint Land-Attack Cruise Missile Defense Elevated Netted Sensor System and PATRIOT through an interface module that supplies battle management data and enables networked operations.



Source: Northrop Grumman.



IAMD entered development in December 2009 with its four critical technologies nearing maturity. However, according to program officials, the technologies will not be fully mature until after the design review in August 2011. As a result, the program will not have demonstrated that the proposed design meets requirements until after the design review, which puts it at risk for late design changes. The platform the IBCS was originally planned to be fielded on will not be available when production begins in 2014, but according to program officials, an alternative has been selected. The cost and schedule of the IAMD program may also be affected by an Army proposal to substitute the IBCS for the current battle management system under development for the Medium Extended Air Defense System (MEADS). If this option is selected for any of the MEADS partners, the development schedule for IAMD will need to be synchronized with MEADS.





## Army IAMD Program

### Technology Maturity

IAMD entered development in December 2009 with its four critical technologies—integrated battle command, integrated defense design, integrated fire control network, and distributed track management—nearing maturity. In August 2009, the Office of the Deputy Assistant Secretary of the Army for Research and Technology approved a technology readiness assessment that stated that all of the critical technologies were tested in a relevant environment using digital simulations. In addition, the integrated fire control network and the distributed track management technologies were demonstrated through hardware tests, and the integrated defense design was demonstrated through a prototype. Program officials estimate that the technologies will be mature by the IAMD production decision in 2014, but not by its planned August 2011 design review.

### Design Maturity

The IAMD program is preparing for its August 2011 design review; however, the risk of late and potentially costly design changes will persist because the program will not have demonstrated that the program's critical technologies are fully mature or the proposed design meets requirements by then. The Army completed a partial preliminary design review prior to development start for the IAMD and its components. The IBCS preliminary design review is complete, and the reviews for IAMD, the interface modules, and the overall integration of the components were expected to be complete in November 2010. Officials stated that the Army expects to modify the IBCS design because the platform it was planned to be fielded on—the High Mobility Multipurpose Wheeled Vehicle—will not be available when it enters production in 2014. The Army and the contractor evaluated alternatives and selected a chassis from the Family of Medium Tactical Vehicles (FMTV) as a replacement. The program is now working on integrating the FMTV chassis into the design for the IBCS.

### Other Program Issues

The cost and schedule of the IAMD program could be affected by an Army proposal to substitute the IBCS for the Battle Management Command, Control, Communications, Computer, and Intelligence (BMC4I) system under development for the MEADS

program. According to Army officials, a number of issues would need to be resolved before the proposal could be adopted. These issues include a decision between the IBCS and BMC4I contractors about whether the substitution is feasible and a decision about whether to adopt it for any or all of the MEADS partners. If any of the MEADS partners agree to the substitution, the development schedule for IAMD will need to be synchronized with MEADS. Specifically, IBCS would be needed for integration testing prior to the MEADS low-rate initial production decision, currently planned for November 2012.

### Program Office Comments

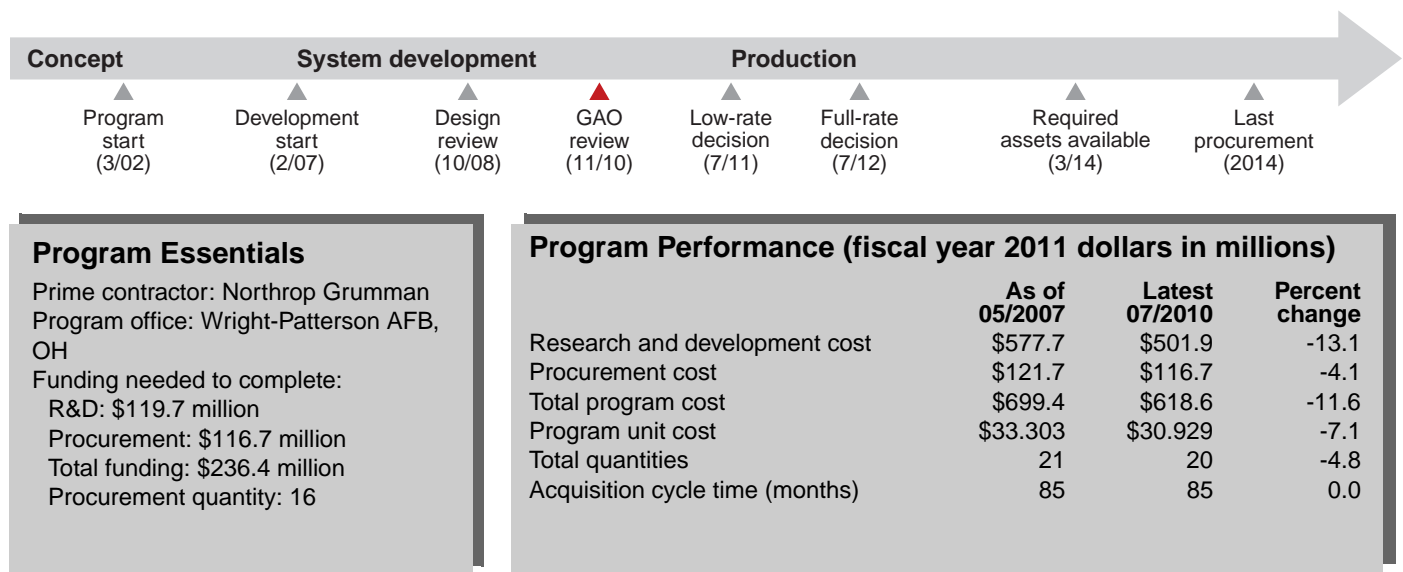
In commenting on a draft of this assessment, the Army stated that the IAMD program entered the engineering and manufacturing development (EMD) phase in December 2009 after a competitive prototyping phase lasting 15 months. During this phase, the competitors (Raytheon and Northrop) developed IBCS prototypes which were demonstrated to the government prior to the selection of one contractor (Northrop). Both contractors were assessed at technology readiness levels necessary for entry into the EMD phase. Subsequently, Northrop's design was reassessed in December 2010, and all critical technologies were at the level needed for the current phase of the program. The program is on track to conduct the critical design review in August 2011. With regards to the insertion of the IBCS into the MEADS program, the Army and the Office of the Secretary of Defense agreed to withdraw the proposal based on cost and schedule considerations. Any use of the IBCS with the MEADS components will be after fiscal year 2016. The Army also provided technical comments, which were incorporated as appropriate.

## B-2 Extremely High Frequency (EHF) SATCOM Capability, Increment 1

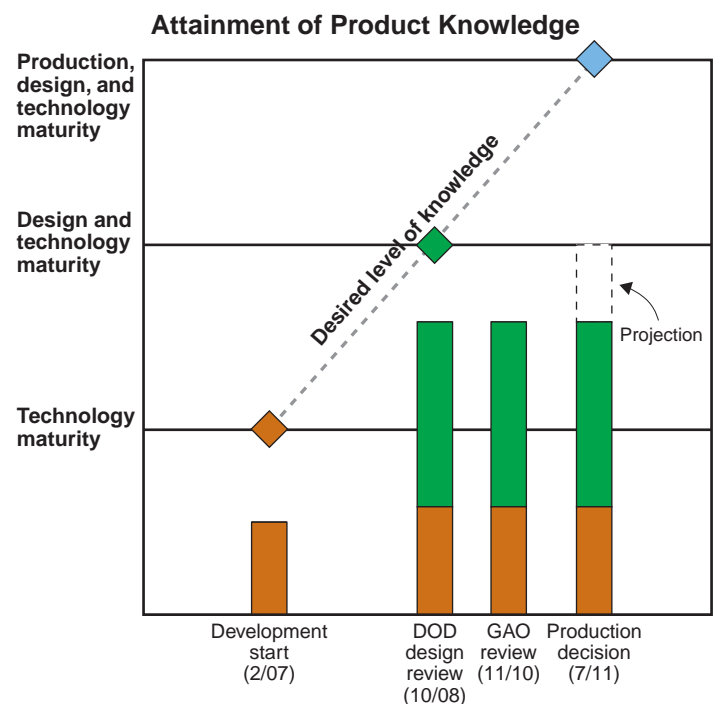
The Air Force's B-2 EHF satellite communications upgrade is being developed in three increments. Increment 1 upgrades the computing system speed and storage capacity of the current avionics infrastructure to facilitate future B-2 upgrades. Increment 2 will provide connectivity through low-observable antennas and radomes, and includes nonintegrated Family of Advanced Beyond Line-of-Sight Terminals and related hardware. Increment 3 will enable connectivity with the Global Information Grid and net-ready capability. We assessed Increment 1.



Source: U.S. Air Force.



According to the program office, the B-2 EHF SATCOM Increment 1 will have mature critical technologies and a stable design by its planned July 2011 low-rate initial production decision. The program office also plans to demonstrate critical manufacturing processes using a pilot production line and high levels of manufacturing readiness for two key technologies prior to the production decision. The program expects an operational assessment to be completed by the Air Force Operational Test and Evaluation Center in early 2011 to support the production decision. The B-2 EHF SATCOM Increment 1 program completed software certification in April 2010 and flight testing began in September 2010, after a 5-month delay. According to the program office, this delay has added pressure to the test schedule and the program's plan to begin initial operational test and evaluation in fiscal year 2012.



## **B-2 EHF SATCOM Increment 1 Program**

### **Technology and Design Maturity**

The B-2 EHF SATCOM Increment 1 program entered system development in February 2007 with all six of its critical technologies nearing maturity. The program office expects all critical technologies to be mature and flight-qualified by the program's planned July 2011 production decision. The B-2 EHF Increment 1 design also appears stable. According to the program office, all of the expected drawings were releasable at the October 2008 design review and the number of design drawings has not grown.

The development and successful integration of new disk drive units and integrated processing units is a primary objective for Increment 1. The Air Force has completed disk drive unit qualification and design verification without discovering any significant issues, and integrated processing unit durability and airworthiness testing was also completed.

### **Production Maturity**

Although we did not fully assess production maturity because the program does not have statistical process control data, we did assess aspects of production maturity. According to the program office, the B-2 EHF SATCOM Increment 1 is based on commercial-off-the-shelf technology with proven manufacturing processes. The program is implementing other practices that will also help demonstrate production maturity. For example, according to the program office, system-level development testing of a fully configured, production-representative prototype in its intended environment began in July 2010, and critical manufacturing processes will be demonstrated on a pilot production line using production-representative articles prior to the July 2011 production decision. In addition, the program plans to complete a manufacturing readiness level assessment to support a production readiness review in April 2011 and demonstrate a high level of manufacturing readiness for the disk drive units and integrated processing units.

### **Other Program Issues**

B-2 EHF SATCOM Increment 1 testing is progressing; however, earlier delays have added schedule risk to the test program. The program completed software certification in April 2010, after

recovering from early software development issues that delayed the start of developmental test and evaluation by 9 months. Flight testing began in September 2010 after a 5-month delay. The delay has added pressure to the current test schedule and increased the schedule risk for the start of initial operational test and evaluation in fiscal year 2012. According to the program office, the delay was a result of installation issues, test aircraft concerns, and higher B-2 testing priorities. The program office has taken steps to address the installation issues and the health of the test aircraft.

### **Program Office Comments**

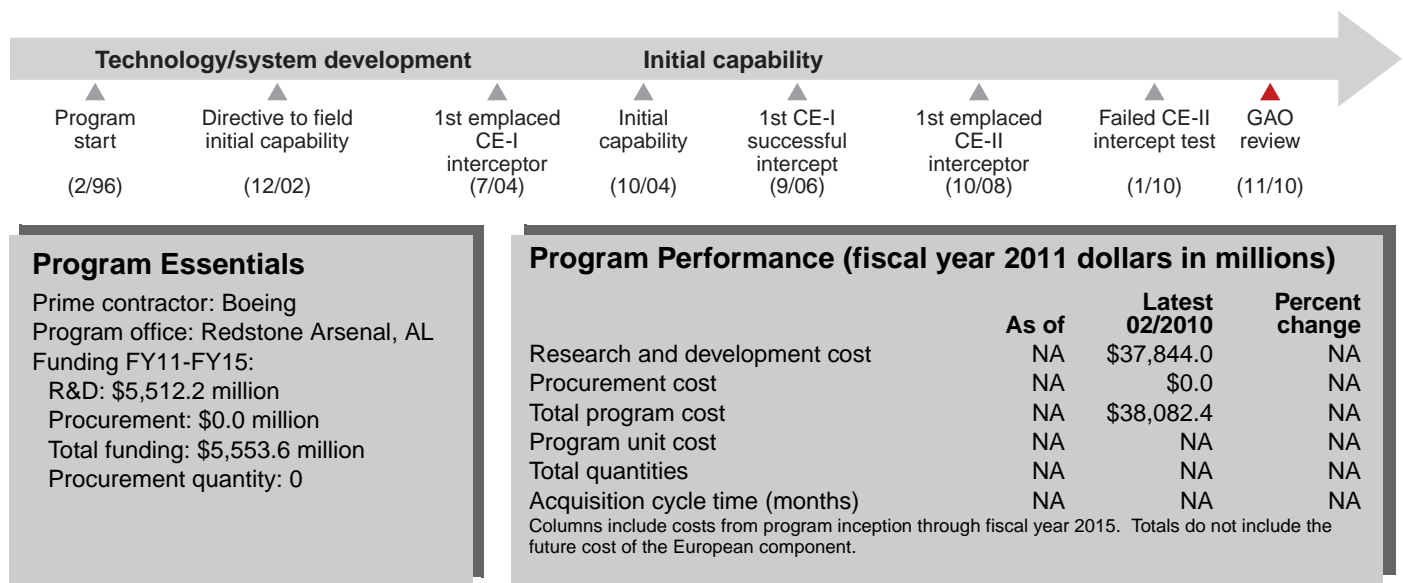
In commenting on a draft of this assessment, the B-2 program office noted that despite the delays in software development and in the start of flight test, the B-2 EHF Increment 1 schedule remains a year ahead of the July 2012 threshold date for its low-rate initial production decision, and 7 months ahead of the September 2012 threshold date for completion of initial operational test and evaluation. The Air Force also provided technical comments, which were incorporated as appropriate.

## BMDS: Ground-Based Midcourse Defense (GMD)

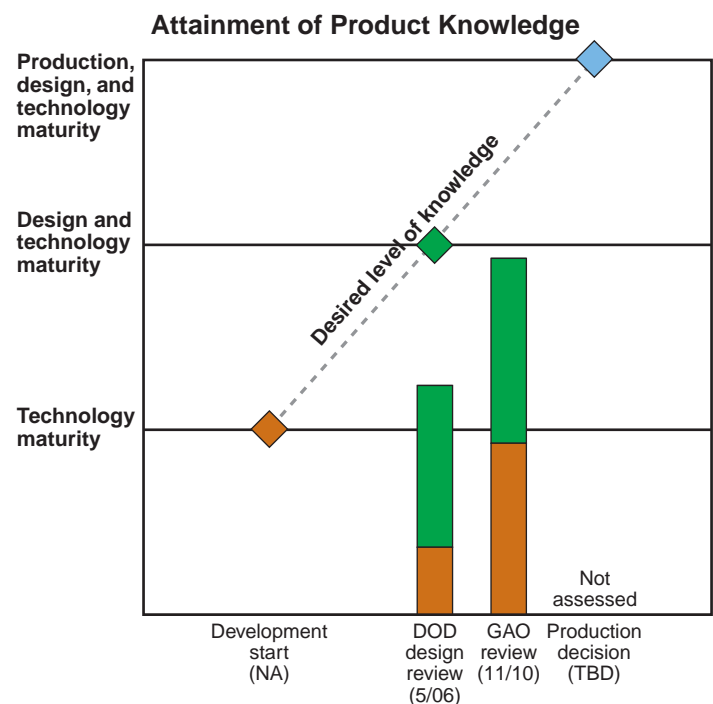
MDA's GMD is being fielded to defend against limited long-range ballistic missile attacks during their midcourse phase. GMD consists of an interceptor with a 3-stage booster and kill vehicle, and a fire control system that formulates battle plans and directs components integrated with BMDS radars. We assessed the maturity of all GMD critical technologies, as well as the design of the Capability Enhancement II (CE-II) configuration of the Exoatmospheric Kill Vehicle (EKV), which began emplacements in fiscal year 2009.



Source: Missile Defense Agency.



MDA continues to put the GMD program at risk for further cost growth and delays as it buys and emplaces CE-II interceptors before all the critical technologies have been demonstrated in a realistic environment. After a 1-year delay, MDA tested the CE-II EKV in January 2010, but it failed to achieve an intercept. GMD reconducted the test in December 2010 and although the booster and EKV were successfully launched, it again failed to achieve an intercept. Almost all of the CE-II kill vehicles currently under contract will have been delivered before the test is successfully conducted. Moreover, developmental testing is expected to continue until fiscal year 2021, well after the last planned EKV deliveries. Due to the concurrent testing and production of the CE-II EKV, the program could experience costly late design changes and retrofits if problems are discovered during flight testing.



## **BMDS: GMD Program**

### **Technology Maturity**

All nine technologies in the GMD operational configuration are mature, but two technologies developed for the CE-II interceptor—an upgraded infrared seeker and onboard discrimination—are nearing maturity. Although the program delivered and fielded more upgraded interceptors in fiscal year 2010, its full capability has yet to be verified through flight tests.

### **Design Maturity**

The design of the enhanced interceptor appears stable with all of its expected drawings released to manufacturing. However, the design could still change because two technologies are still being developed and have not had their capability verified through flight testing.

### **Production Maturity**

We did not assess the maturity of the production processes for the GMD interceptors. The program is buying interceptors for operational use, but officials do not plan to make an official production decision or collect statistical control data because the planned quantities are small. However, according to GMD officials, the program does track defects per unit for each major interceptor component. In addition, GMD employs a manufacturing capability assessment process in which all critical manufacturing indicators are assessed on a monthly basis.

### **Other Program Issues**

GMD continues to concurrently develop, manufacture, and field the CE-II EKV's putting it at risk for further cost growth, schedule delays, and performance shortfalls in delivered capability. After experiencing over a 1-year delay, GMD conducted an intercept flight test to assess the capability of the CE-II EKV in January 2010; however, it did not intercept the target because of a failure in the EKV. GMD reconducted this test in December 2010. Although the booster was successfully launched and deployed the EKV, it failed to intercept the target. The next flight test will be determined after identification of the cause of the failure. Although the emplaced CE-II ground-based interceptors (GBI) have not been declared operational, the production of the CE-II is nearly complete. Consequently, the

program is at risk for costly late design changes and retrofits if problems are discovered during flight testing.

In fiscal year 2010, GMD conducted a nonintercept flight test of its two stage GBI, which was originally designed for a European site. Although all flight test objectives were achieved, an EKV anomaly was experienced that might affect system performance.

MDA is currently developing plans to sustain the GMD element through 2032; however, key unknowns and a lack of analysis have hindered these efforts. In fiscal year 2010, GMD continued to develop its fleet rotation strategy and aging and surveillance test plan and completed its stockpile reliability plan. GAO has been unable to fully assess these efforts because they lack key analysis. For example, the sufficiency of the planned inventory of operational GBIs is based on various assumptions, including the reliability of the interceptor. However, developmental testing is expected to continue until at least 2021 and the reliability of the interceptor is not fully known.

### **Program Office Comments**

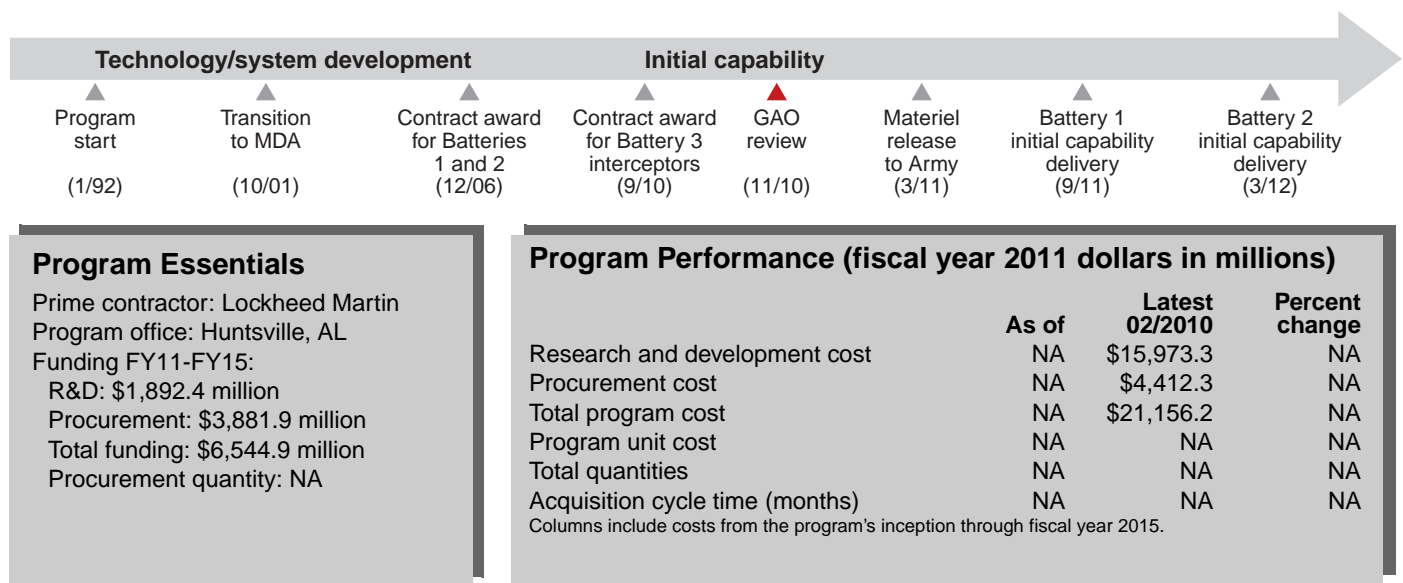
The program office provided technical comments, which were incorporated as appropriate.

## BMDS: Terminal High Altitude Area Defense (THAAD)

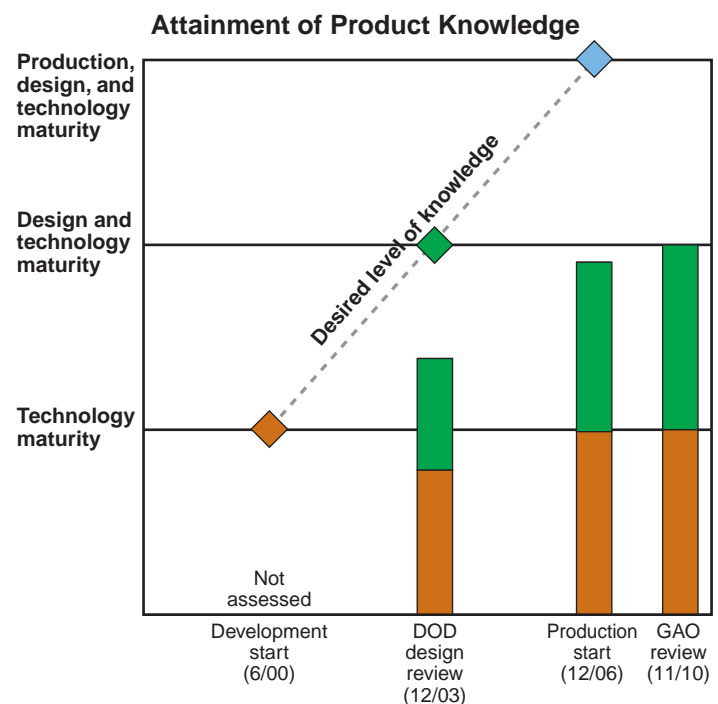
MDA's THAAD is being developed as a rapidly-deployable, ground-based missile defense system with the capability to defend against short- and medium-range ballistic missiles during their late midcourse and terminal phases. A THAAD battery includes interceptor missiles, three to six launchers, an X-band radar, and a fire control and communications system. MDA is scheduled to deliver the first two of nine planned THAAD batteries to the Army in fiscal years 2011 and 2012 for initial operational use.



Source: Missile Defense Agency.



THAAD has mature technologies and has had a production contract since 2006, but the program is still experiencing design and production issues. Problems with a safety switch have caused interceptor production issues, design changes, and schedule delays. Deliveries of Batteries 1 and 2 have been delayed at least 1 year; the number of design drawings has increased by more than 20 percent since production began due to the switch redesign and other related changes; and the Army's acceptance of THAAD batteries has been delayed 6 months until testing on the switch is complete. Most THAAD ground component deliveries for Batteries 1 and 2 are complete, but there will be a production gap of more than a year for future battery ground and missile components, which could increase costs. In fiscal year 2010, THAAD successfully proved out its objective software in flight testing.





## **BMDS: THAAD Program**

### **Technology and Design Maturity**

The THAAD program's major components—the fire control and communications system, interceptor, launcher, and radar—are mature. According to the program office, the prime contractor has released 100 percent of the expected design drawings. However, the number of design drawings has increased by more than 20 percent since production started in December 2006, due primarily to fire control risk reduction efforts, design changes for a safety system called an optical block that prevents inadvertent launches, and associated changes to the flight sequencing assembly, which houses the optical block. Additional drawings or design work could still be required based on the results of remaining ground and flight testing.

### **Production Maturity**

MDA awarded a contract for its first two initial operational batteries in December 2006 before completing developmental testing on all the system's critical components and has experienced production delays as a result. While we did not assess THAAD's overall production maturity because the program has not collected statistical process control data on its critical manufacturing processes, the program's production readiness assessments highlighted a number of risks including design producibility and qualification of critical components. The delivery of the first two batteries has been delayed by at least a year after these risks materialized in parts of the THAAD interceptor. A qualified optical block design failed during integration qualification testing in early fiscal year 2010 due to contamination during manufacturing. The program changed to cleaner manufacturing processes and subsequently completed this qualification testing in September 2010. According to program officials, the program plans to develop a more producible design of the optical block for use on future THAAD battery interceptors. All of the ground components necessary for Batteries 1 and 2 have been delivered except for the launchers which are experiencing a 2 year delay in completing the government acceptance process because of production issues as well as delays to the qualification process due to design changes. In addition, discoveries during a recent ground test have led to further design changes. The

launchers are expected to complete the government acceptance process by the end of the third quarter of fiscal year 2011.

### **Other Program Issues**

The THAAD program delayed its conditional release of batteries to the Army from September 2010 until March 2011 because of ongoing safety issues with interceptor components. For the release to occur, the Army must certify that the batteries are safe, suitable, and logistically supported. According to program officials, the results from optical block safety testing in February 2011 are needed before the release board can make its decision.

The THAAD program is facing a production gap that poses cost and schedule risks. Product qualification issues delayed contract award for Battery 3 interceptors by approximately 6 months to the end of fiscal year 2010, and there will be as much as a 1-year production gap for some interceptor components. The program did not plan to award the contract for THAAD ground components and Battery 4 interceptors until the first quarter of fiscal year 2011, which means there will be a production gap of up to 3 years for some ground components. As a result of these gaps, the program will have to retrain workers and recertify and requalify parts. The effect of these gaps on cost is not yet known.

Despite test delays due to target issues, the program was able to conduct one flight test in June 2010 to successfully demonstrate the complete objective software for the THAAD battery.

### **Program Office Comments**

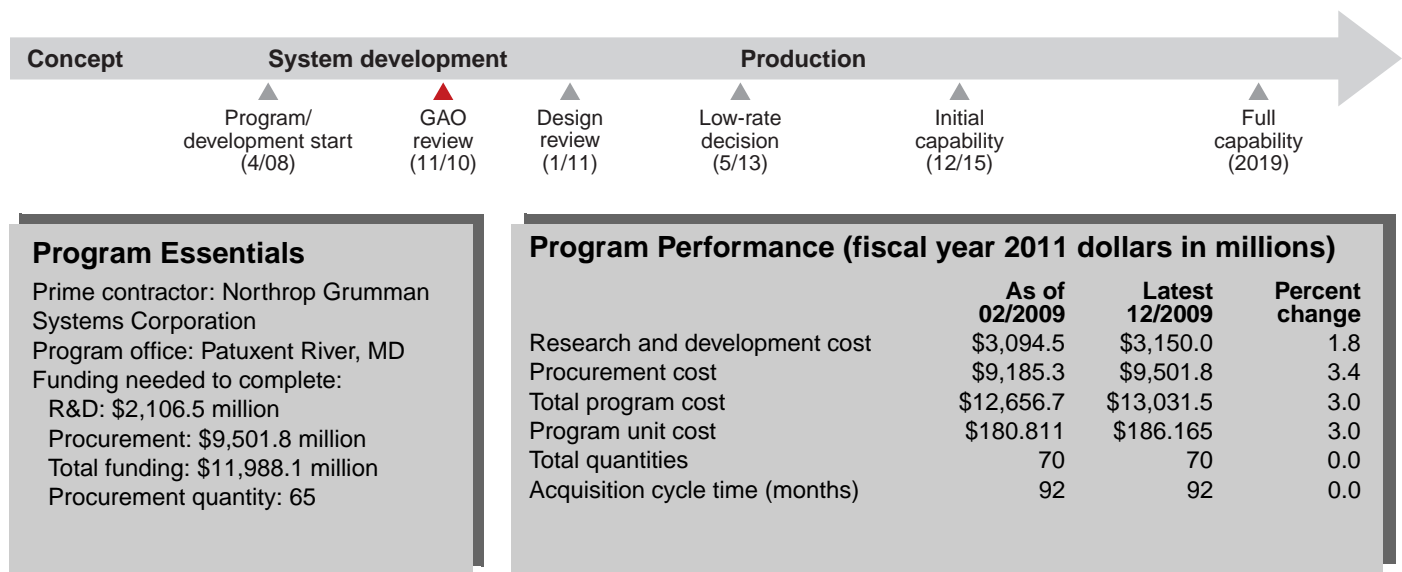
Program officials stated that the THAAD program is significantly more mature than indicated in the "Attainment of Product Knowledge" graph and associated language. At production start all production design was completed except for two items associated with the fire control and interceptor. At the time of this review, none of the interceptors for the THAAD batteries were delivered, but all THAAD system and component qualifications were completed except for two interceptor-related tests. All but one of the subassemblies for each of the 50 interceptors was delivered. Other technical comments were incorporated as appropriate.

## Broad Area Maritime Surveillance (BAMS) Unmanned Aircraft System (UAS)

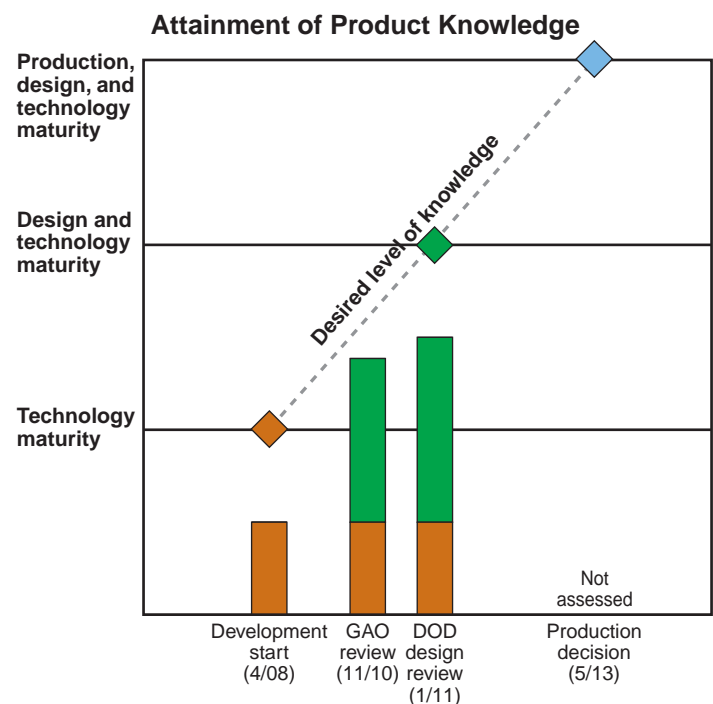
The Navy's Broad Area Maritime Surveillance Unmanned Aircraft System (BAMS UAS) is intended to provide a persistent maritime intelligence, surveillance, and reconnaissance (ISR) capability. BAMS UAS will be part of a family of maritime patrol and reconnaissance systems that recapitalizes the Navy's airborne ISR assets. Increments 2 and 3 of the program will upgrade the system's communication relay and add a signals intelligence capability. We assessed Increment 1.



Source: U.S. Navy.



The BAMS UAS program began development in 2008 with all technologies nearing maturity and plans to demonstrate its design is stable by its critical design review in January 2011. The program office continues to monitor six watch-list items that were identified in a 2007 independent technology readiness assessment that could affect the program's cost, schedule, and performance. The BAMS UAS program plans to enter production in May 2013. According to program officials, the BAMS air vehicle is based on the RQ-4B Global Hawk and uses sensor components or entire subsystems from other existing platforms. There are some structural changes to the airframe, but none of these require significant changes to manufacturing processes. The program expects to purchase two developmental aircraft and begin testing prior to production.





## **BAMS UAS Program**

### **Technology Maturity**

DOD and the Navy certified that all BAMS UAS technologies were nearing maturity and had been demonstrated in a relevant environment before the start of system development. The program is monitoring six watch-list items that were identified in a 2007 independent technology readiness assessment, which could cause cost, schedule, or performance issues during development. According to the program, the Navy conducted an additional independent technology readiness assessment after the program's February 2010 preliminary design review. DOD was reviewing the results at the time of our assessment.

### **Design Maturity**

The BAMS UAS program expects the air vehicle's design to be stable by its January 2011 critical design review. However, the program will be at risk for design changes until it integrates all of its key subsystems and components and tests them through an integration laboratory or an early system prototype demonstration. This will not occur until January 2012. According to the program office, about 79 percent of the BAMS UAS air vehicle's expected drawings are releasable to manufacturing and 8 of the 11 subsystem critical design reviews have been successfully completed.

### **Production Maturity**

The BAMS aircraft is based on the Global Hawk RQ-4B currently in production, and, according to program officials, uses sensor components or entire subsystems from other existing platforms. There are some significant changes to the airframe, such as deicing and structural reinforcements for the wings, but none of these require significant manufacturing process changes. The program expects to purchase two developmental aircraft and begin testing them prior to production.

### **Other Program Issues**

In 2010, the Joint Requirements Oversight Council directed the Navy and Air Force to seek efficiencies in the Global Hawk and BAMS UAS programs. According to BAMS UAS program officials, the Air Force and Navy programs are investigating commonality opportunities in areas such as sense-and-avoid capabilities, a common ground control station architecture, a consolidated maintenance

hub, and basing options for both UASs. According to program staff, thus far, only minor changes to the configuration of the BAMS UAS are anticipated.

The BAMS UAS program is also continuing to leverage knowledge from the BAMS demonstrator program. The demonstrator consists of two Block 10 Global Hawk UASs. It is used to support BAMS UAS design activity, test ground station capabilities, and develop concepts of operations. For example, a BAMS UAS official noted the demonstrator has been successful using mission operating bases, which conduct data analysis and operate flight controls, located in the continental United States. As a result, the program office plans to update its concept of operations to reflect this lesson learned. According to the program, forward operating bases, responsible for launch and recovery of the aircraft, will remain in theater as planned.

The BAMS UAS program poses a significant software development challenge. The program will utilize more than 6 million lines of code, including more than 1 million lines of new code. Total lines of code have increased by about 13 percent since development start, which according to the program, were the result of selecting a different sense-and-avoid radar subsystem, and shifting from reused code to new software for the synthetic aperture radar. The program is closely monitoring the software effort and software is being developed in three blocks of capability to decrease risks.

### **Program Office Comments**

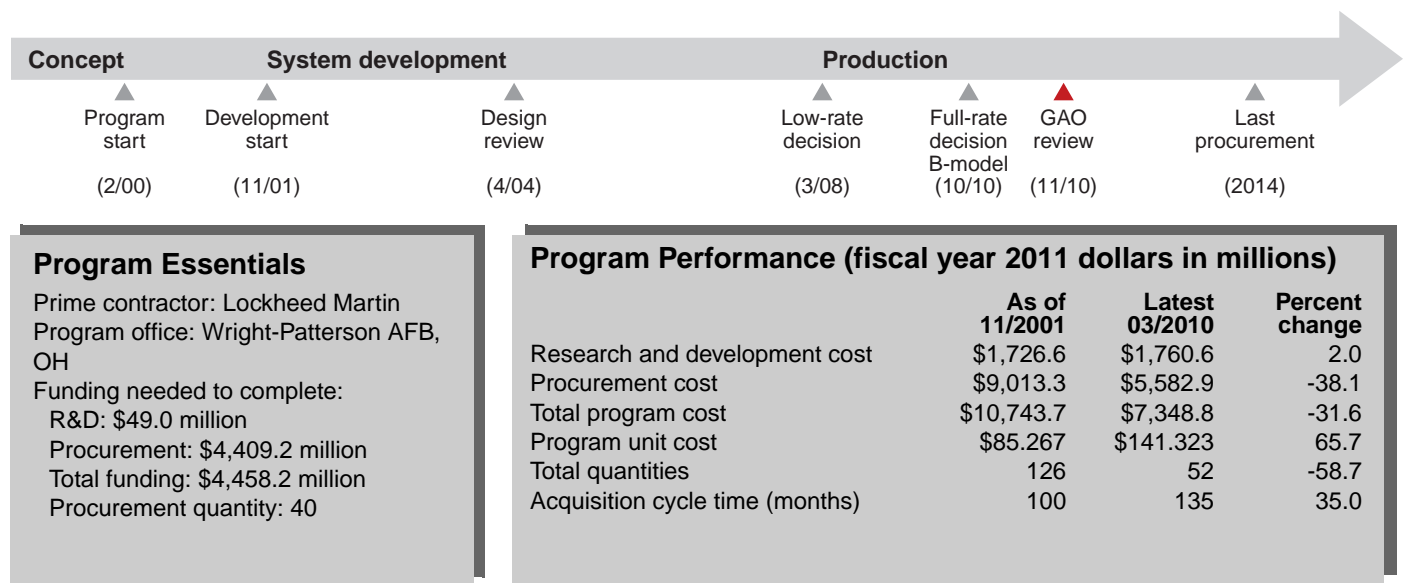
According to the Navy, the program continues to meet its cost, schedule, and performance requirements. In support of the engineering and manufacturing development decision, the Navy stated that the Office of the Secretary of Defense assessed the technology and determined BAMS had been demonstrated in a relevant environment, since the program leverages existing DOD investment in its airframe, engine, avionics, payloads, and software. The Navy also stated that the program is capturing and applying lessons learned from the programs it is leveraging in order to maximize its effectiveness and efficiency. Furthermore, the Navy stated that the BAMS UAS and Air Force Global Hawk programs continue to work closely together to seek synergistic opportunities in all phases of the programs. The Navy also provided technical comments, which were incorporated as appropriate.

## C-5 Reliability Enhancement and Reengining Program (C-5 RERP)

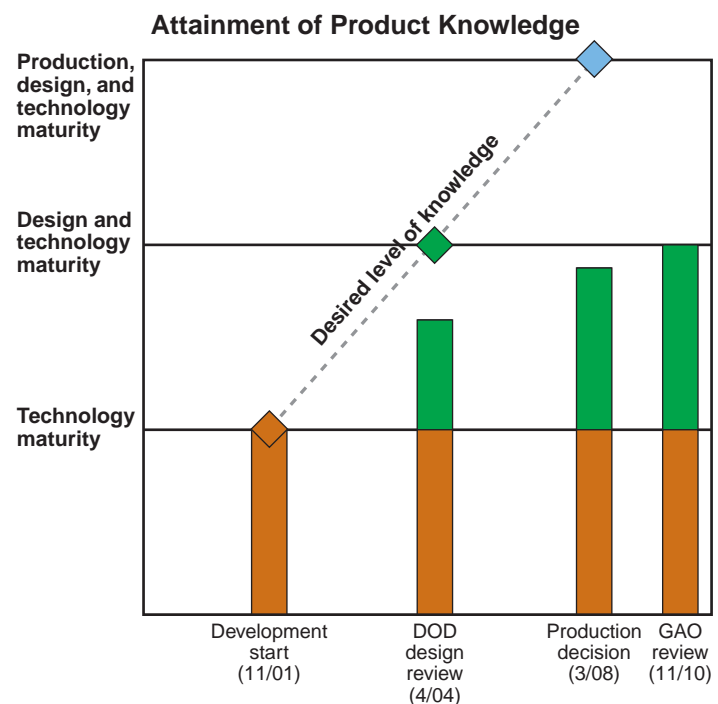
The Air Force's C-5 RERP is one of two major upgrades for the C-5. The RERP is designed to enhance the reliability, maintainability, and availability of the C-5 by replacing the propulsion system; modifying the mechanical, hydraulic, avionics, fuel, and landing gear systems; and making required structural modifications. Together with the C-5 Avionics Modernization Program, these upgrades are intended to improve C-5 mission capability rates and reduce total ownership costs.



Source: Lockheed Martin.



The C-5 RERP entered production in March 2008 with mature technologies and a design that was nearing completion. We did not assess production maturity because the program office does not require process control data to be collected. To determine the program's readiness to enter full-rate production, the program completed a manufacturing readiness assessment, which concluded its manufacturing processes were capable, in control, and affordable. The assessment was performed on the first low-rate initial production aircraft and may not reflect all manufacturing risks. A production aircraft was not used for initial operational testing. The Air Force test organization found the system to be effective, suitable, and mission capable; however, it noted that incomplete development and testing of the aircraft's defensive systems and thrust reversers increased the risk of operating in certain environments.



## C-5 RERP Program

### Technology and Design Maturity

According to an independent technology readiness assessment conducted in October 2001, the C-5 RERP's technologies are mature. In addition, the C-5 RERP design is stable.

### Production Maturity

The C-5 RERP program entered production in March 2008. We did not assess production maturity because the program office does not require process control data to be collected as part of the production contract. In order to determine the program's readiness to enter full-rate production, the Air Force and the prime contractor, Lockheed Martin, performed a manufacturing readiness assessment in early 2010. According to the final report, a manufacturing readiness assessment is normally conducted near the end of low-rate initial production. However, the assessment was performed on the first low-rate initial production aircraft while it was in production and may not reflect all the manufacturing risks. Program officials stated that conducting the assessment at the beginning of low-rate initial production was driven by full-rate production decision requirements established in an acquisition decision memorandum and the expected date of the decision. The Air Force accepted delivery of the first production aircraft in October 2010.

The C-5 RERP program's manufacturing assessment concluded that the manufacturing risk was understood and that the manufacturing processes for the system were capable, in control, and affordable. The assessment identified what program officials believe to be two minor issues with the aircraft engine's thrust reverser, which will not affect production, and an air exit door that could affect production. According to program officials, design changes are being made to the thrust reverser to prevent freezing and will be ready for testing in April 2011. The thrust reverser modifications will be installed on all modernized C-5 aircraft, including those that have already been upgraded. The malfunctioning air exit door will be addressed through a change to production processes and will not require additional flight testing. The program expects all aircraft in the modernized C-5 fleet to eventually receive modified air exit doors.

### Other Program Issues

The Commander, Air Force Operational Test and Evaluation Center, found the C-5 RERP to be effective, suitable, and mission-capable during operational testing conducted from October 2009 to January 2010. The Air Force did not provide a low-rate initial production aircraft for operational testing as recommended by the Director, Operational Test and Evaluation, because one was not available. However, according to program officials, a production-representative aircraft was used in operational testing. According to the test report, the modified development aircraft increased the C-5 maximum operating weight, significantly surpassed its reliability requirement, and performed its required mission better than the C-5 legacy fleet. However, the Air Force test organization also noted that incomplete development and testing of the aircraft's defensive systems and thrust reversers increased the risk of operating in certain environments.

In February 2010, DOD released the Mobility Capabilities Requirements Study-2016, which concluded that the Air Force has excess strategic airlift capacity. As a result, the Air Force is requesting approval to retire 22 C-5A aircraft. This would reduce the number of aircraft in the C-5 Avionics Modernization Program, but it would not affect the number of aircraft in the C-5 RERP program.

### Program Office Comments

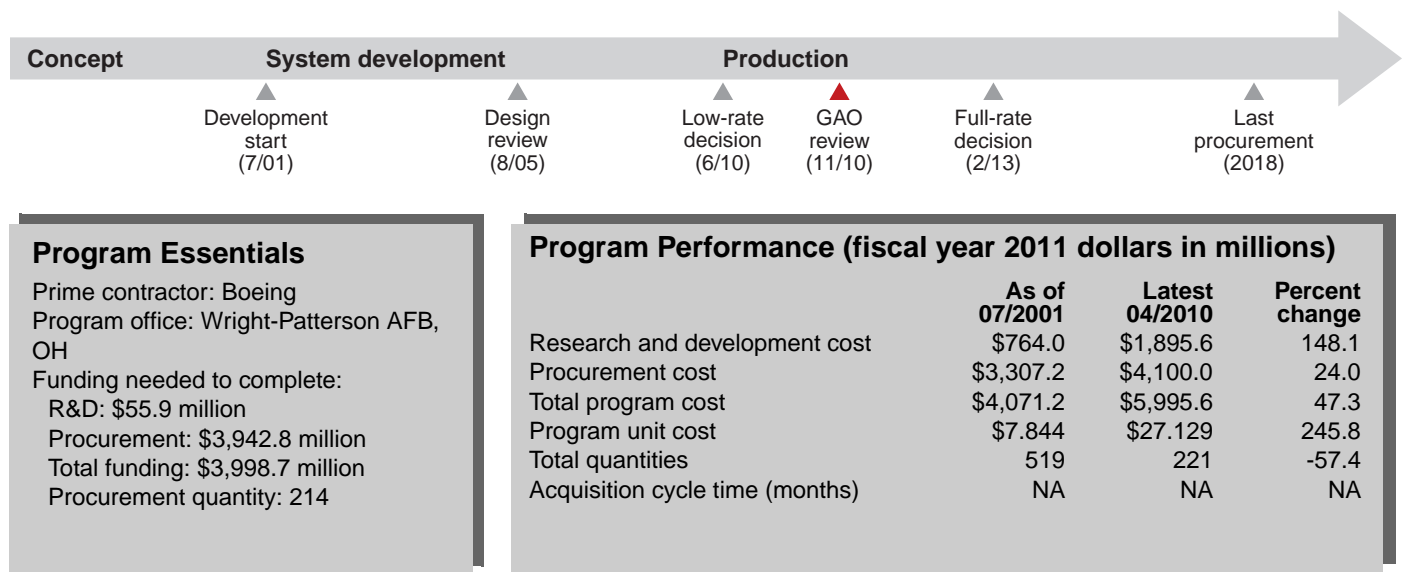
The Air Force provided technical comments to a draft of this assessment, which were incorporated as appropriate.

## C-130 Avionics Modernization Program (C-130 AMP)

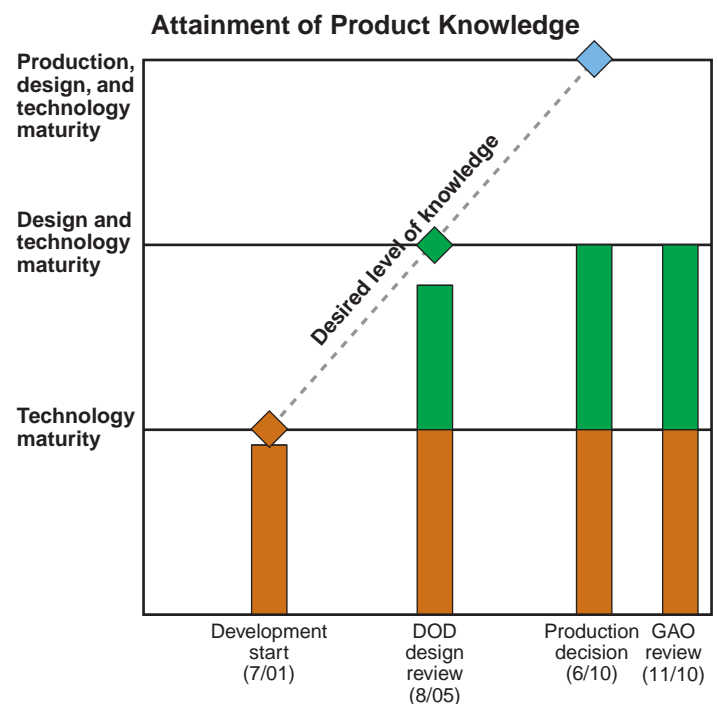
The Air Force's C-130 AMP will standardize the cockpit and avionics for three combat configurations of the C-130 fleet. The program is intended to ensure the C-130 global access and deployability by satisfying navigation and safety requirements, installing upgrades to the cockpit systems, and replacing many systems no longer supportable due to diminishing manufacturing resources. It is also expected to increase the reliability, maintainability, and sustainability of the upgraded aircraft.



Source: C-130 Avionics Modernization Program.



The C-130 AMP program entered production in June 2010 with mature technologies and a stable design. The program reported that it demonstrated critical manufacturing processes prior to production; however, it did not assess manufacturing readiness levels at key suppliers and installation facilities. The first two aircraft to receive the AMP upgrade have begun the modification process. During low-rate production, the program plans to qualify a second contractor to compete for the full-rate production contract. In February 2010 the program reported a Nunn-McCurdy unit cost breach of the significant cost growth threshold, which it attributed to factors such as the omission of training devices and adequate spares from initial estimates, and delays in the production decision. The program has been restructured and planned dates for key events have been pushed back by more than 1 year.



## **C-130 AMP Program**

### **Technology and Design Maturity**

The C-130 AMP program's three current critical technologies—global air traffic management, defensive systems, and combat delivery navigator removal—are mature. After a Nunn-McCurdy unit cost breach of the critical cost growth threshold in 2007, the program was restructured and the number of critical technologies was cut from six to three. The removed technologies were intended for Special Mission C-130 aircraft configurations, which were eliminated from the program. The design of the C-130 AMP combat delivery configuration is stable, with all of the expected drawings releasable to manufacturing.

### **Production Maturity**

The C-130 AMP program reported that it demonstrated critical manufacturing processes using production-representative articles prior to entering production, but it did not assess manufacturing readiness levels at key suppliers and installation facilities. Program officials reported that they will perform these assessments during low-rate production and develop manufacturing maturity plans as needed in order to demonstrate its readiness to begin full-rate production. We did not assess the overall production maturity of the program because it does not collect statistical process control data on its critical manufacturing processes. However, the program does track quality metrics related to the numbers of nonconformance and corrective action reports, as well as the percentage of inspection points passed.

### **Other Program Issues**

After 2 years of delays and the threat of program cancellation, the C-130 AMP received approval to enter production in June 2010. The first two aircraft scheduled for AMP kit installation began the modification process in August and October 2010, respectively. During low-rate production, the program will conduct a full and open competition to select a second contractor. The program will qualify the second contractor by providing installation and maintenance training, and the second contractor will perform up to five low-rate production kit installations. This contractor will compete with the current contractor for the full-rate production contract, which includes the procurement of 198 kits and up to 141 kit installations. The competition and

planned contract award for the second source have been delayed by about 4 months to early 2011 and early 2012, respectively, because the program has changed the acquisition approach for this effort. These delays could affect the program's planned entry into full-rate production in early 2013.

The C-130 AMP program has completed developmental testing, which identified key deficiencies in the areas of crew workload and avionics. Specifically, testing found that the core avionics were not well adapted to the C-130 tactical missions, and identified the need to reduce crew workload during airdrop, low-level, and certain formation operations. The program plans to develop additional software builds to correct these issues. However, the program has reported a delay in awarding the contract for one of these software builds, which could affect its ability to begin operational testing in fiscal year 2012 as planned.

In February 2010, the C-130 AMP program reported a Nunn-McCurdy unit cost breach of the significant cost growth threshold after the average procurement unit cost increased by almost 18 percent over its existing baseline. According to the program office, the cost breach was due to the omission of training devices and adequate spares in initial program estimates, inflation, delays in the program's production decision, and a change in the kit installation strategy. The program has been restructured, and the completion of operational testing and low-rate production kit installation, as well as the full-rate production decision, are now scheduled to occur more than 1 year later than previously planned.

### **Program Office Comments**

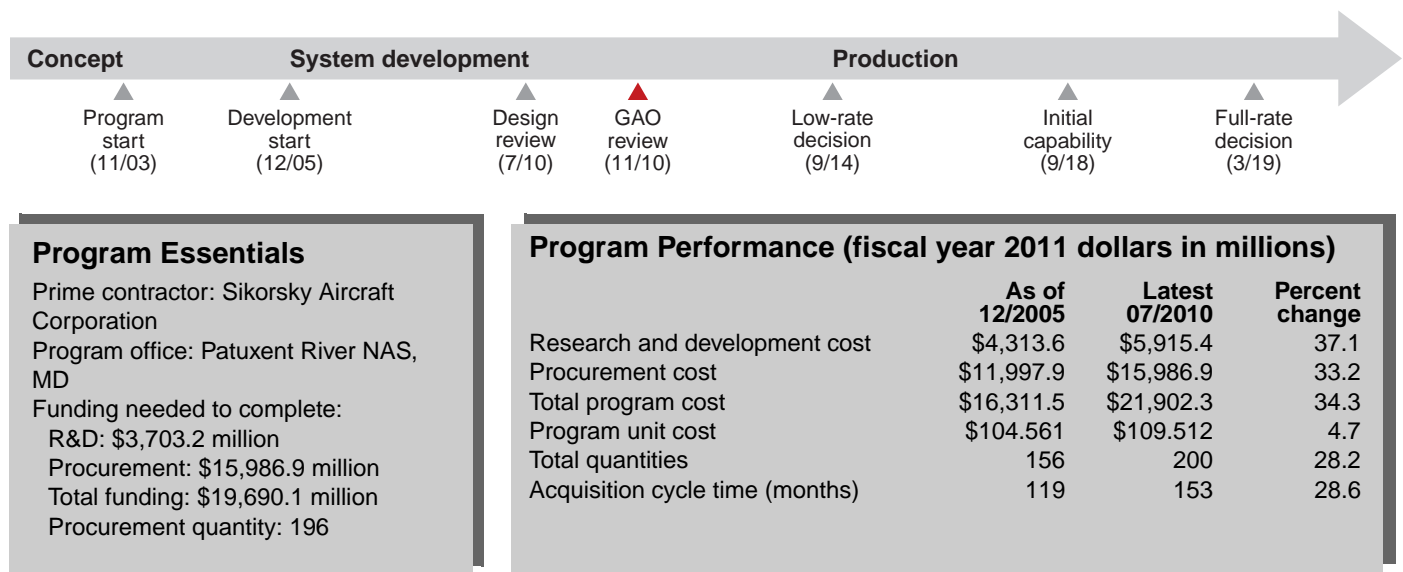
The program office concurred with this assessment.

## CH-53K - Heavy Lift Replacement

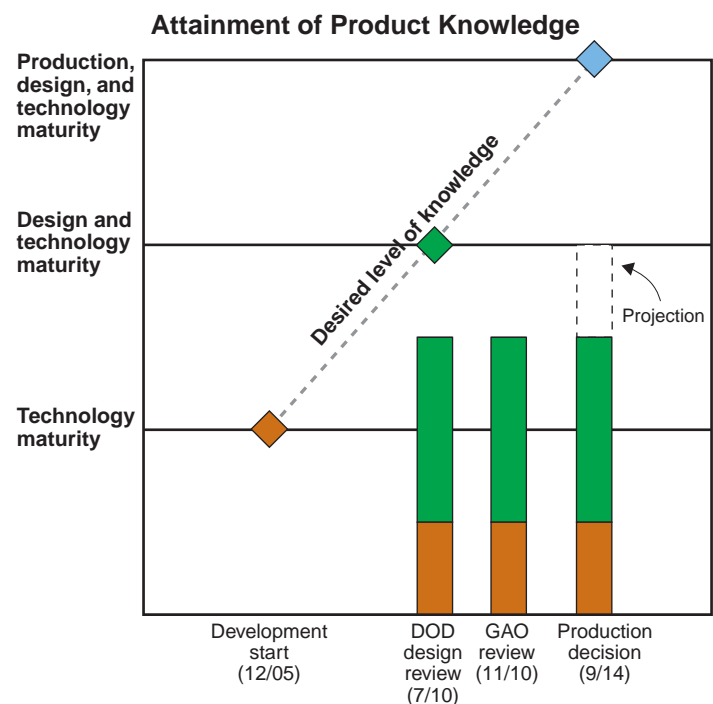
The Marine Corps' CH-53K helicopter will perform heavy-lift assault transport of armored vehicles, equipment, and personnel to support operations deep inland from a sea-based center of operations. The CH-53K program is expected to replace the legacy CH-53E helicopter and improve range and payload, survivability and force protection, reliability and maintainability, and coordination with other assets, while reducing total ownership cost.



Source: © 2008 Sikorsky Aircraft Corporation.



According to program officials, both CH-53K current critical technologies are nearing maturity and are expected to be fully mature by its production decision in 2014. A third technology, the viscoelastic lag damper, has been replaced with a modified version of an existing technology to reduce cost and weight. The program completed its design review in July 2010—16 months later than planned—with over 90 percent of its total expected design drawings released. Developmental testing and initial operational capability have been delayed, and the overall cost of development has increased by \$1.7 billion. The program is revising its acquisition strategy to move the start of production up by 1 year to align with its production decision. The program will also update its schedule and cost estimate. As it stands now, delivery of the capability will occur more than 2 years later than planned.





## CH-53K Program

### Technology Maturity

The CH-53K program began development in 2005 with three critical technologies, all of which were immature. One of these technologies, the viscoelastic lag damper, was replaced by a modified version of an existing technology to reduce cost and weight. According to the program office, the CH-53K's two remaining critical technologies—the main rotor blade and the main gearbox—were nearing maturity when the program's design review was held in July 2010. The program office plans for these technologies to be fully mature and demonstrated in a realistic environment prior to its production decision in 2014.

### Design Maturity

The CH-53K design appears stable. In July 2010, the program office completed its critical design review with over 90 percent of total expected design drawings released. However, the continuing maturation of critical technologies could result in design changes as testing progresses.

### Other Program Issues

CH-53K developmental testing and initial operational capability have been delayed, and the overall cost of development has increased by \$1.7 billion. To avoid further cost and schedule problems, the program has taken several steps, including allowing more time to review the design and deferring certain requirements. For example, the program delayed its critical design review to ensure that all subsystems had completed their design reviews before moving forward. In addition, the program has received approval to defer three net ready capabilities—variable message format (VMF), mode 5, and link 16—to later in production to reduce development costs. According to the program office, deferring these capabilities would save approximately \$103.5 million in the near term. However, it will also decrease the initial capability that is delivered to the warfighter. The program is currently revising its acquisition strategy to move the start of production up by 1 year to align with its production decision. Currently, there is a 1-year gap between the production decision date and the scheduled start of production. According to the program office, it is also updating its schedule and cost estimates.

Delays in the CH-53K program may result in the extended use of and increased costs for legacy systems, such as the CH-53E and CH-53D helicopter. Currently deployed CH-53E aircraft are flying at almost three times the planned utilization rate. This operational pace is expected to result in higher airframe and component repair costs, as the Marine Corps seeks to minimize CH-53E inventory reductions until CH-53K deliveries reach meaningful levels. According to program officials, all available decommissioned CH-53E and CH-53D helicopters have been reclaimed and all available parts have been salvaged to keep the current inventory of aircraft in service. However, as a cost-saving measure, the Marine Corps now plans to begin retiring the entire CH-53D fleet earlier than anticipated.

In 2008, the program office was directed to increase the number of planned CH-53K aircraft from 156 to 200 to accommodate an increase in Marine troop levels from 174,000 to 202,000. The quantity increase added \$5 billion in procurement cost to the program.

### Program Office Comments

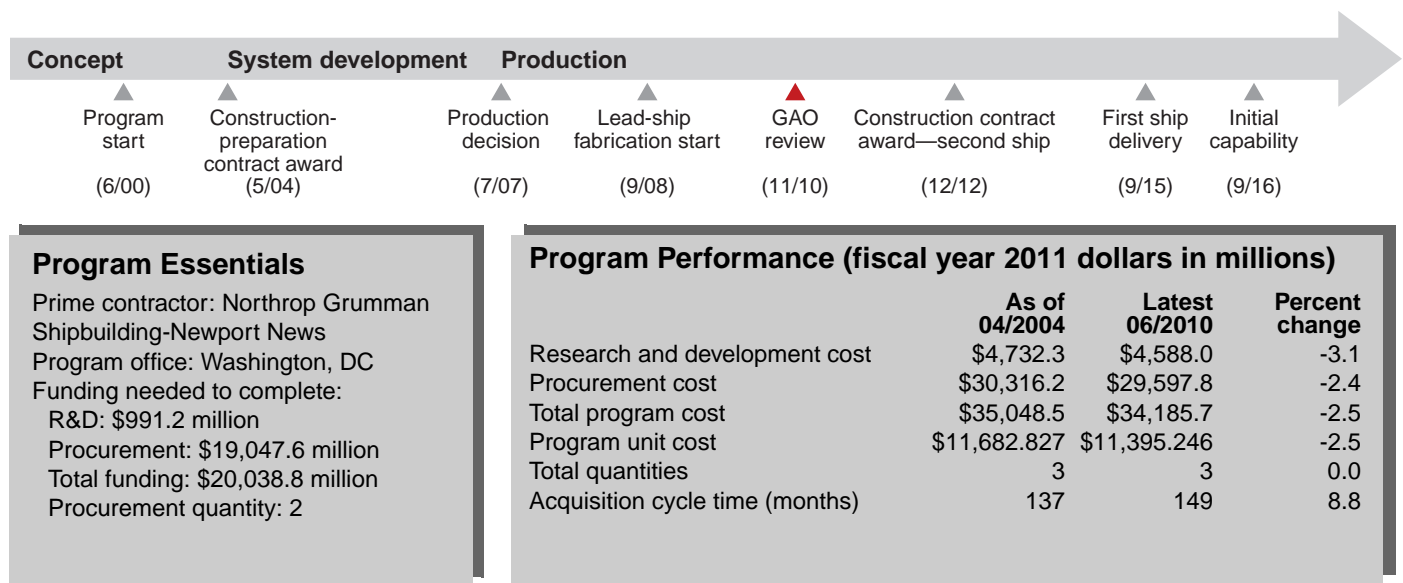
In its comments on a draft of this assessment, the Navy stated that, during 2010, the CH-53K program completed the critical design review and began assembly of the engineering development model test articles. Critical technologies are maturing as planned in the approved technology maturation plan. In August 2010, the Director, Defense Research and Engineering, certified that both critical technology elements had achieved technology readiness level 6, which is the appropriate level of maturity for this stage of program development. The President's 2011 budget fully funded the program to achieve a fiscal year 2018 initial operational capability. The Navy also provided technical comments, which were incorporated as appropriate.

## CVN 21 Future Aircraft Carrier

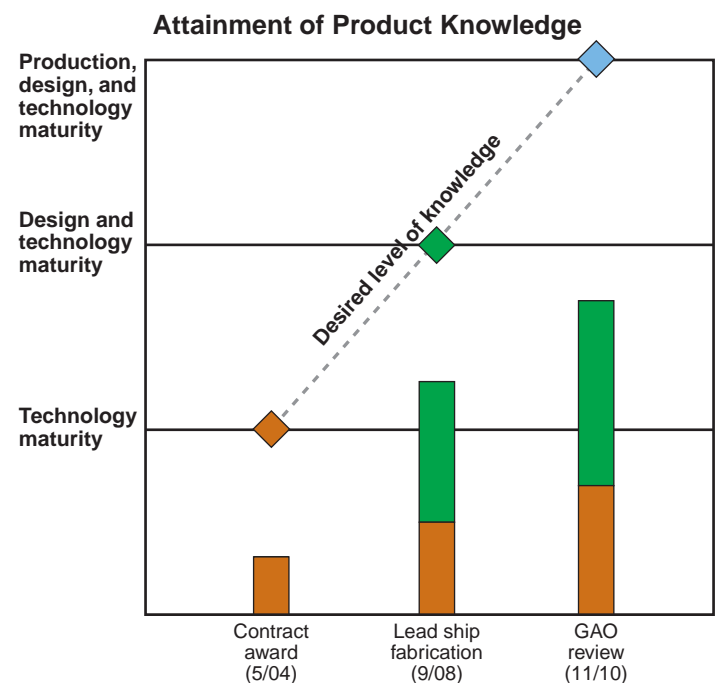
The Navy's CVN 21 program is developing a new class of nuclear-powered aircraft carriers. The carriers will include advanced propulsion, aircraft launch and recovery, and survivability technologies designed to improve operational efficiency, enable higher sortie rates, and reduce manpower. The Navy awarded a contract for detail design and construction of the lead ship, CVN 78, in September 2008 and expects delivery of the ship by September 2015. The Navy plans to award a construction contract for the second ship, CVN 79, in December 2012.



Source: U.S. Navy.



CVN 78 began construction in September 2008. However, 7 of the program's 13 critical technologies are still not fully mature because they have not been demonstrated in a realistic, at-sea environment. Of these technologies, the electromagnetic aircraft launch system (EMALS), advanced arresting gear, and dual band radar present the greatest cost and schedule risk. The ship's three-dimensional product model was completed in November 2009, but the contractor is making design changes and could experience more as EMALS and other systems complete testing. Seventy-two percent of the ship's structural units are complete, accounting for about 19 percent of the total production hours. A number of units are behind schedule due to late materials. The program's shift from a 4- to 5-year build cycle could increase costs if it results in the type of inefficiencies predicted by the shipbuilder.





## CVN 21 Program

### Technology Maturity

Seven of the CVN 21 program's 13 current critical technologies have not been demonstrated in a realistic, at-sea environment. Of these technologies, EMALS, the advanced arresting gear, and dual band radar present the greatest risk to the ship's cost and schedule. Program officials stated that EMALS development has been one of the primary drivers of CVN 78 cost increases. Problems have occurred in EMALS testing which could result in more design changes later in the program. Testing uncovered a crack in the motor, which has already resulted in several design changes; and in January 2010, a motor controller software error caused damage to the EMALS hardware. Both fixes have successfully been retested. The program completed the first four F/A-18E launches in December 2010. The advanced arresting gear is nearing maturity and has completed extended reliability testing. However, delays in land-based testing with simulated and live aircraft could lead to late delivery. The Navy finalized a fixed-price production contract for EMALS and the advanced arresting gear in June 2010. Although the Navy continues to pay design and testing costs, any EMALS changes identified during development will be incorporated into the production units at no cost to the government. The dual band radar, which includes the volume search and multifunction radars, is being developed by the DDG 1000 destroyer program and is also nearing maturity. However, as a part of a program restructuring, the DDG 1000 eliminated the volume search radar from the program. According to Navy officials, radar development has not been affected, but CVN 78 will now be the first ship to operate with this radar. Radar equipment will be delivered for installation and testing beginning September 2011 for the multifunction radar and in January 2012 for the volume search radar.

### Design Maturity

In September 2008, CVN 78 began production with only 76 percent of its three-dimensional product model complete. The three-dimensional product model was completed by November 2009, but the contractor is currently making design changes to prevent electrical cable routing from interfering with other design features. As EMALS and other systems complete testing, additional design changes may be necessary.

### Production Maturity

The Navy awarded the CVN 78 construction contract in September 2008. Construction of approximately 65 percent of the ship's structural units is complete. These units account for about 19 percent of the ship's total production hours. As of July 2010, construction of the hull in dry dock was behind schedule because of late material deliveries from suppliers.

### Other Program Issues

In 2010, the CVN 21 program shifted from a 4- to 5-year build cycle, which could increase program costs. According to program officials, the shipbuilder projects that this change will increase costs by 9 to 15 percent due to the loss of learning and effect on the supplier base, among other inefficiencies. The Navy disagrees with this assessment and reported to Congress that the shift will have minimal negative consequences. The dual band radar also presents cost risks for the program. Program officials are considering buying the radar for both CVN 79 and CVN 80 at the same time, in order to reduce the risks associated with the production line being idle for up to 5 years. However, this strategy could lead to increased costs if changes identified during at-sea testing on CVN 78 need to be incorporated into the already-procured systems for the two follow-on ships.

### Program Office Comments

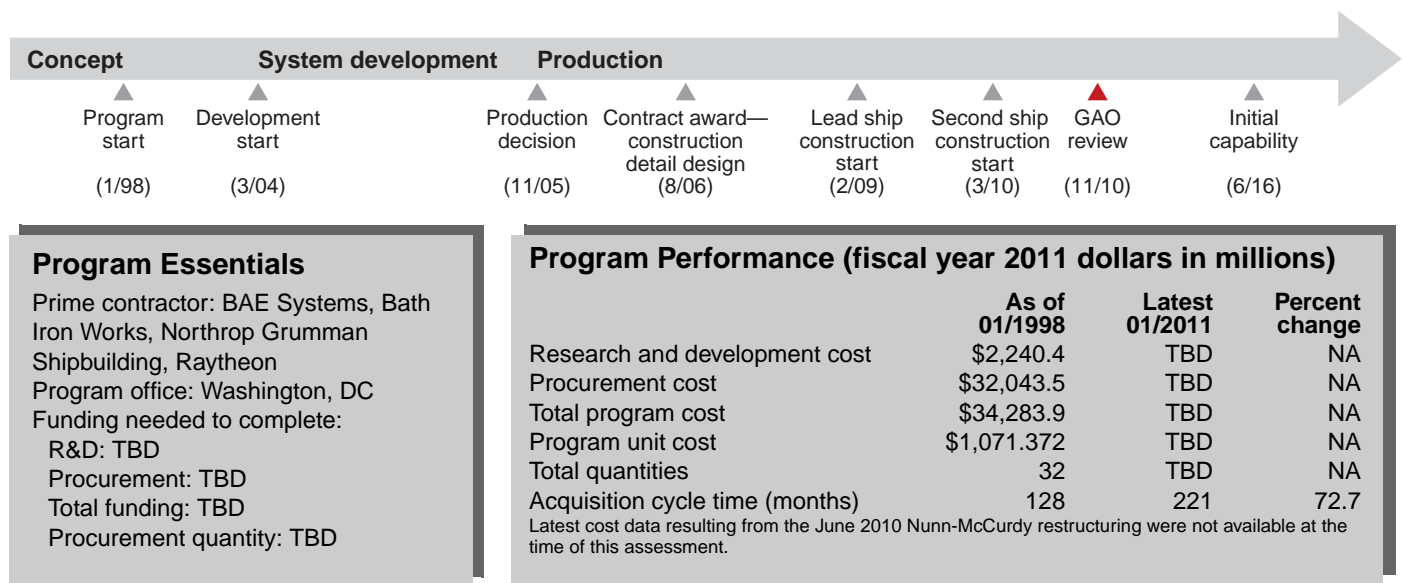
In commenting on a draft of this assessment, the Navy generally concurred with this assessment. Officials stated the program is addressing the technology and construction challenges for a successful September 2015 delivery, and that CVN 79 is on track to award a construction contract by the first quarter fiscal year 2013. The Navy stated that while the change from a 4- to 5-year build cycle will increase the unit cost of the CVN 78 class carrier, it facilitates a reduced average yearly funding requirement over a longer period of time. The Navy also provided technical comments, which were incorporated as appropriate.

## DDG 1000 Destroyer

The Navy's DDG 1000 destroyer is a multimission surface ship designed to provide advanced land-attack capability in support of forces ashore and littoral operations. Construction has begun on the first and second ships, and the Navy anticipates awarding a construction contract for the third ship in the second quarter of fiscal year 2011. Bath Iron Works will build all three ships in this class with key segments built by Northrop Grumman Shipbuilding Gulf Coast.



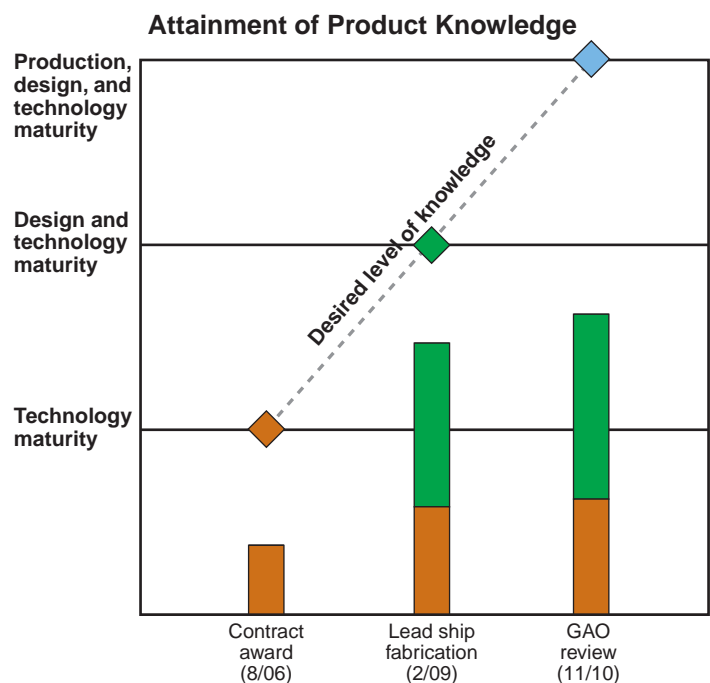
Source: U.S. Navy.



### Program Essentials

Prime contractor: BAE Systems, Bath Iron Works, Northrop Grumman Shipbuilding, Raytheon  
 Program office: Washington, DC  
 Funding needed to complete:  
 R&D: TBD  
 Procurement: TBD  
 Total funding: TBD  
 Procurement quantity: TBD

The second ship in the DDG 1000 class began construction in March 2010 with a complete design. While all 12 of the program's critical technologies are now nearing maturity or are fully mature, 8 of these technologies will not be demonstrated in a realistic environment until after installation on the first ship. Software development for the total ship computing environment also continues to be a challenge. In fiscal year 2008, the Navy truncated the DDG 1000 program to three ships, triggering a critical Nunn-McCurdy cost breach and a restructure of the program. DOD removed the volume search radar from the baseline design and will modify software for the remaining multifunction radar to meet volume search requirements. The restructured program delayed initial operational capability by 1 year to allow additional time for the program to retire remaining software and production risks.



## DDG 1000 Program

### Technology Maturity

Three of DDG 1000's 12 critical technologies are mature, and the remaining 9 have been demonstrated in a relevant environment. The Navy plans to fully demonstrate the integrated deckhouse before installation on the ship, but the remaining 8 technologies will not be demonstrated in a realistic environment until after ship installation. The design review for one of the technologies—the ship's long-range land-attack projectile—was delayed from 2010 to 2011 to allow time to correct issues found during rocket motor testing, but program officials noted that the projectile has performed well and met accuracy and range requirements in flight tests completed to date. The total ship computing environment (phased over six releases and one spiral) is now nearing maturity, and, according to program officials, the integration and testing of software release 5 is complete. However, software development challenges remain. According to the Defense Contract Management Agency (DCMA), there has been significant cost growth due to testing delays for release 5, and several unresolved problems have been deferred to release 6. DCMA has reported that these deferred requirements, coupled with software requirements changes for release 6, could create significant cost and schedule challenges.

### Design Maturity

The DDG 1000 design appears stable. The design was 88 percent complete at the start of lead ship construction and 100 percent complete shortly thereafter.

### Production Maturity

The first DDG 1000 began construction in February 2009 and the Navy estimates that approximately 30 percent of the ship is complete. Fabrication of the second ship began in March 2010, and 38 percent of the units that make up the ship are now in various stages of production. The Navy reported that it contractually requires the shipbuilders to specify detailed structural attributes to be monitored during unit fabrication and integration in order to reduce the risk of rework. While the shipbuilders are not currently meeting some of the production metrics, program officials reported that these issues have been addressed in part by retraining personnel.

### Other Program Issues

In fiscal year 2008, the Navy truncated the DDG 1000 program to three ships, triggering a Nunn-McCurdy unit cost breach of the critical threshold and a restructure of the program. To reduce program costs, DOD removed the volume search radar from the design, leaving only the multifunction radar on the ship. According to program officials, removing the volume search radar will save the program \$300 million and will not preclude DDG 1000 from meeting its key performance parameters. However, the software for the multifunction radar will have to be modified to provide a volume search capability that meets all planned threat scenarios. The program office has not yet estimated the cost of these multifunction radar modifications; it does not expect them to affect the program's schedule. According to program officials, the ship could accept the volume search radar in the future because space and weight will be reserved, but there are currently no plans to include it. The program restructure also delayed initial operational capability by 1 year to the third quarter of fiscal year 2016 to allow additional time for the program to retire remaining software and production risks. The program expects all three ships to be operational by 2018.

### Program Office Comments

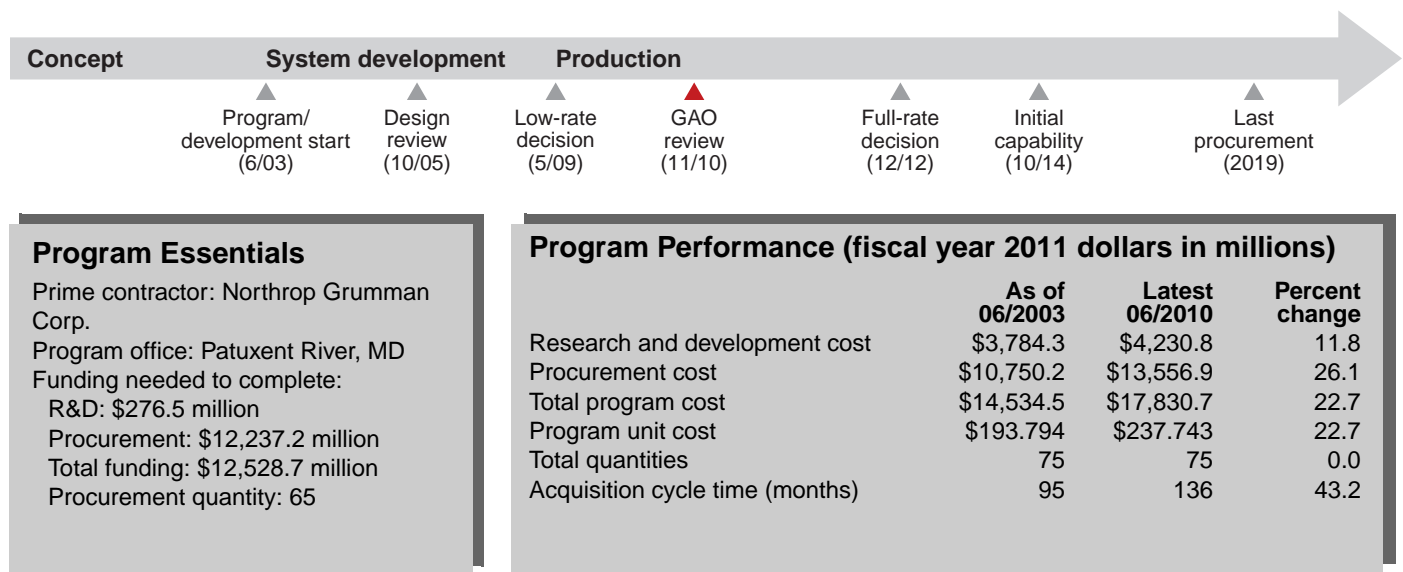
In commenting on a draft of this assessment, the Navy stated that the program received milestone B approval, after the critical Nunn-McCurdy breach, in October 2010 and is closely monitoring and managing risk through comprehensive program metrics, program reviews, and an earned value management system. At the time of the review, all critical technologies had been at the appropriate level of maturity for the program phase. Earned value assessments of both shipbuilders and an independent logistics assessment are to be completed in fiscal year 2011. All 26 major mission systems equipment are in production and on track for on-time delivery to the shipyard. Software release 6 is on track to support land-based testing for the propulsion system and light off of the main engine. The first advanced gun system magazine was delivered on time and the first gun has been shipped for testing. A successful test mission readiness review and associated tests for the multifunction radar were completed in September 2010. The Navy also provided technical comments, which were incorporated as appropriate.

## E-2D Advanced Hawkeye (E-2D AHE)

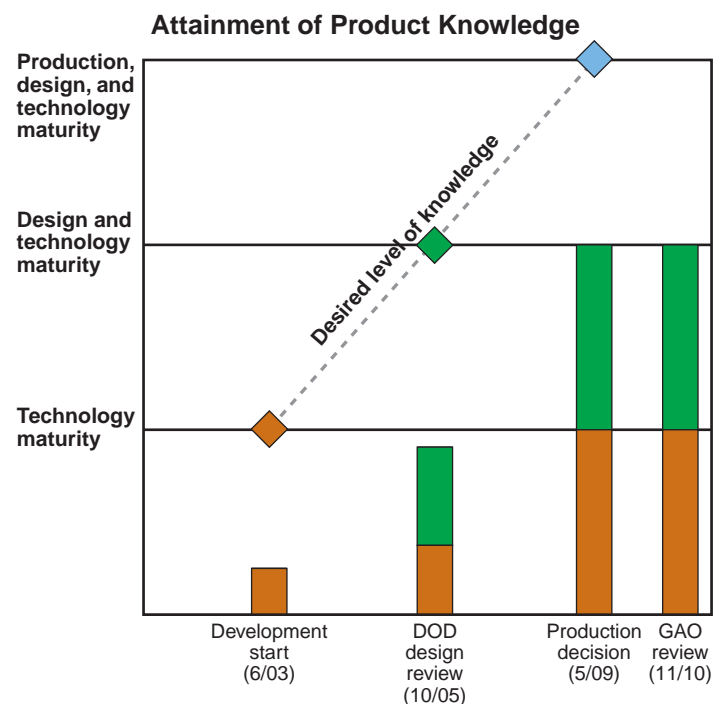
The Navy's E-2D AHE is an all-weather, twin-engine, carrier-based aircraft designed to extend early warning surveillance capabilities. It is the next in a series of upgrades the Navy has made to the E-2C Hawkeye platform since its first flight in 1971. The key objectives of the E-2D AHE are to improve target detection and situational awareness, especially in the littorals; support theater air and missile defense operations; and provide improved operational availability for the radar system.



Source: U.S. Navy.



The E-2D AHE was approved for entry into production in May 2009 with all its critical technologies mature and its design stable. We did not assess production maturity; however, according to E-2D program and Defense Contract Management Agency officials, the contractor is performing well on a variety of production metrics and inspections have not identified any significant concerns. The program must complete a second operational assessment and improve radar reliability before it can award its next production contract. According to program officials, the Navy completed a second operational assessment in November 2010. However, the program's test plan for improving the reliability of the radar system remains aggressive. The program also experienced delays in development testing and the delivery of pilot production aircraft related to a now-resolved problem with the engine mount design.



## **E-2D AHE Program**

### **Technology Maturity**

According to the Navy, all five of the E-2D AHE's critical technologies are mature. The Navy completed a technology readiness assessment in 2009 to support the program's low-rate initial production decision, and DOD concurred with that assessment. The assessment included one new critical technology—the high-power UHF circulator. In the assessment, DOD raised concerns about the UHF transmitter's durability and its potential effect on life-cycle costs and operational availability. According to program officials, the durability of the parts has improved as a result of increased quality control efforts.

### **Design Maturity**

The E-2D AHE design is stable. Program officials said that all current design drawings are releasable, but some design changes will be necessary to incorporate recent modifications to the aircraft, including those related to an engine heat shield puncture issue discovered during carrier suitability testing.

### **Production Maturity**

We did not assess production maturity; however, according to E-2D program and Defense Contract Management Agency officials, the contractor is performing well on a variety of postproduction metrics, and inspections have not identified any significant concerns. The contractor reports monthly to the Defense Contract Management Agency and the program office on a series of production metrics, such as scrap and rework rates, and the program office reported that the contractor is meeting its rework goal. The program did not identify any critical manufacturing processes associated with the E-2D AHE, nor does the program require the contractor's major assembly site to use statistical process controls to ensure its critical processes are producing high-quality and reliable products because components are assembled using manual processes that do not lend themselves to such measures.

### **Other Program Issues**

The E-2D AHE program must complete a second operational assessment and improve radar reliability before it can award its next production contract. The program plans to award this contract after a

March 2011 Defense Acquisition Board review of the program's progress. According to program officials, the Navy completed a second operational assessment in November 2010. However, the program's test plan for improving the reliability of the radar system remains aggressive. The radar must demonstrate a reliability rate greater than or equal to 65 hours. As of November 2010, the program reported a radar reliability rate of 46.7 hours. Program officials expect that the radar will exceed the 65-hour threshold by the March review because some corrective actions have already been implemented, several fixes for identified root causes are waiting to be implemented, and few new types of errors are occurring. According to program officials, forthcoming software updates should address a number of existing failures and improve reliability.

The program also experienced delays in development testing and the delivery of pilot production aircraft related to a now-resolved problem with the engine mount design discovered during carrier suitability testing. Specifically, engine movement led to a temperature sensor puncturing a heat shield and making contact with a bulkhead during simulated aircraft carrier landings. In response, certain carrier landing tests were stopped and other flight tests reduced from October 2009 through July 2010 while the program implemented a new engine mount design to address the problem. The program office decided to adopt this design modification and others on the program's three pilot production aircraft, which resulted in a 3- to 4-month delay in the delivery of each aircraft. According to program officials, the third pilot production aircraft was delivered in November 2010.

### **Program Office Comments**

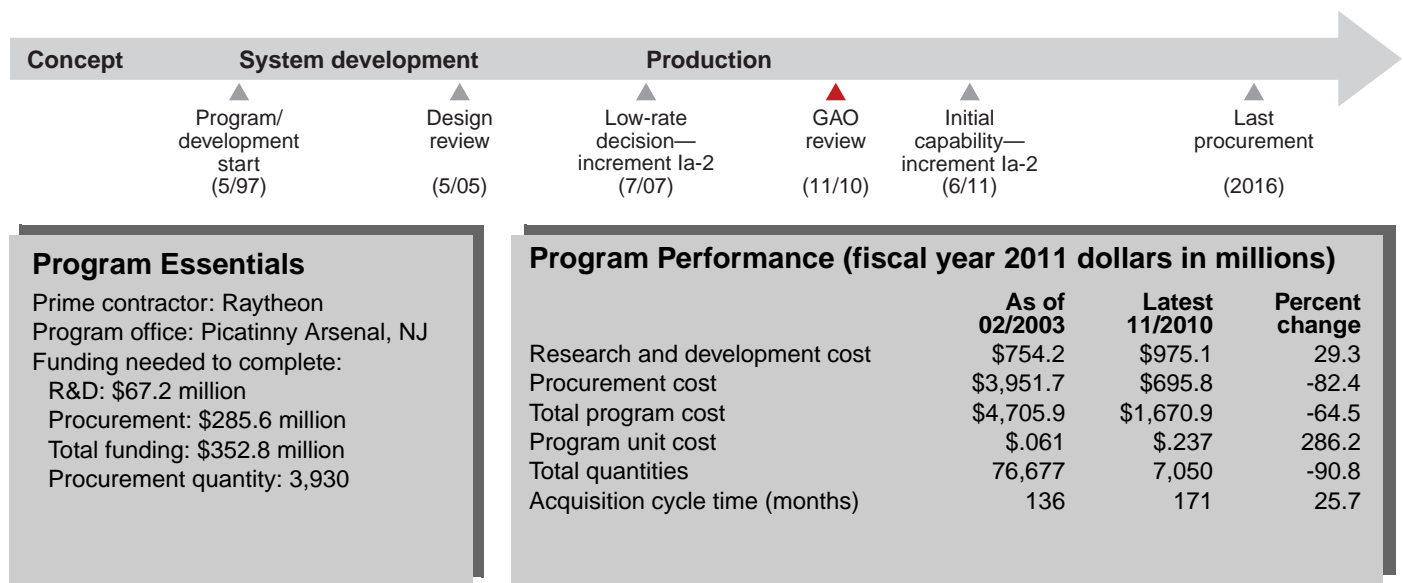
In commenting on a draft of this assessment, the program office provided technical comments, which were incorporated as appropriate.

## Excalibur Precision Guided Extended Range Artillery Projectile

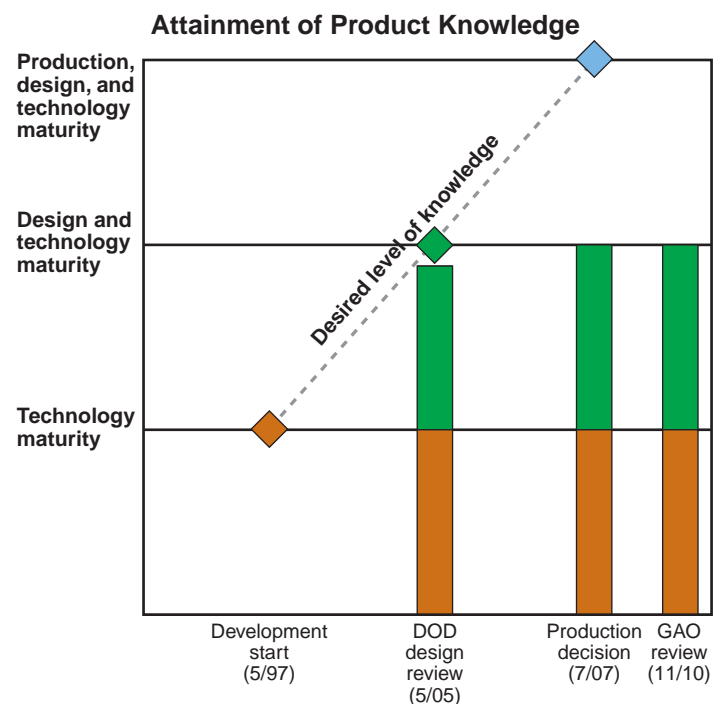
The Army's Excalibur is a family of global positioning system–based, fire-and-forget, 155 mm cannon artillery precision munitions intended to provide improved range and accuracy. The near-vertical angle of fall is expected to reduce collateral damage, making it more effective in urban environments. The Army plans to develop the unitary warhead version in three increments—Ia-1, Ia-2, and Ib. We assessed increments Ia-1 and Ia-2 and made observations on increment Ib.



Source: U.S. Army.



Excalibur increments Ia-1 and Ia-2 are in production. According to program officials, their critical technologies are mature and designs are stable. The program received approval to begin production of increment Ia-1 in May 2005 to support an urgent requirement in Iraq and Afghanistan. Increment Ia-2 entered production in July 2007 and completed initial operational test in February 2010. After a design and prototype demonstration phase, the Army began engineering and manufacturing development for increment Ib in August 2010. The two critical technologies for this increment are mature. In May 2010, the Army reduced overall program quantities from 30,000 to 6,264 based on a review of precision munition needs. The resulting unit cost increase led to a Nunn-McCurdy breach of the critical threshold. The program expects to be certified to continue in early 2011.





## **Excalibur Program**

### **Technology Maturity**

The Excalibur's three critical technologies for increments Ia-1 and Ia-2—the airframe, guidance system, and warhead—are mature. According to the program office, the technologies were demonstrated in a realistic environment at the time of their respective design reviews in May 2005 and March 2007. After an 18-month prototype design and demonstration phase, the Army began engineering and manufacturing development for increment Ib in August 2010. According to program officials, the two critical technologies for this increment—the guidance systems and safe-and-arm fuze—are mature. The contractor for increment Ib plans to leverage existing technology from the increment Ia program.

### **Design Maturity**

The Excalibur increment Ia-1 and Ia-2 designs are stable. According to the program office, more than 90 percent of each increment's expected design drawings were releasable at the time of their design reviews. The number of design drawings increased by almost 20 percent between increment Ia-1 and Ia-2. According to a program official, the increase was due to parts changes on increment Ia-1, as well as upgrades and changes for increment Ia-2.

### **Production Maturity**

The Excalibur program appears to have overcome a series of quality lapses that increased program costs, halted deliveries, and delayed the qualification of the Ia-2. As a result of those problems, the program manager asked the contractor to review acceptance procedures and implement processes to control product quality. The program also qualified a new supplier for the inertial measurement unit—a part of the projectile's guidance system—which has improved program reliability. While we could not assess Excalibur's overall production maturity because statistical process controls have not been implemented at the system level, the program is taking steps to utilize these controls at the assembly plants and subcontractors. The contractor has started to compile these data and, as production continues and quantities increase, plans to look for key areas at the subcontractor level to place under control.

### **Other Program Issues**

The Excalibur program is following an incremental acquisition strategy. Increment Ia-1 Excalibur was fielded in Iraq and first used in combat in 2007. The program office reported that over 85 percent of the rounds expended in combat operations have functioned as expected. The program plans to complete production of increment Ia-1 in fiscal years 2010 and 2011. Increment Ia-2 is currently in production and completed initial operational test and evaluation in February 2010. During operational tests, it demonstrated an overall reliability rate of 73 percent by successfully completing 35 of 48 shots. The increment Ib projectile, which is planned to increase reliability and lower unit costs, is scheduled to begin production in fiscal year 2012.

In May 2010, the Army reduced overall program quantities from 30,000 to 6,264 based on a review of precision munition needs. The resulting unit cost increase—from \$47,000 to \$99,000 per projectile—led to a Nunn-McCurdy breach of the critical threshold. Congress was notified of the breach in August 2010. The program expects to be restructured and certified by the Secretary of Defense to continue in January 2011. As a result of the Nunn-McCurdy breach, the program projects the full-rate production decision for increment Ia-2 will move from August 2010 to February 2011. The effects of the program restructure on increment Ib are still being determined by the program office.

### **Program Office Comments**

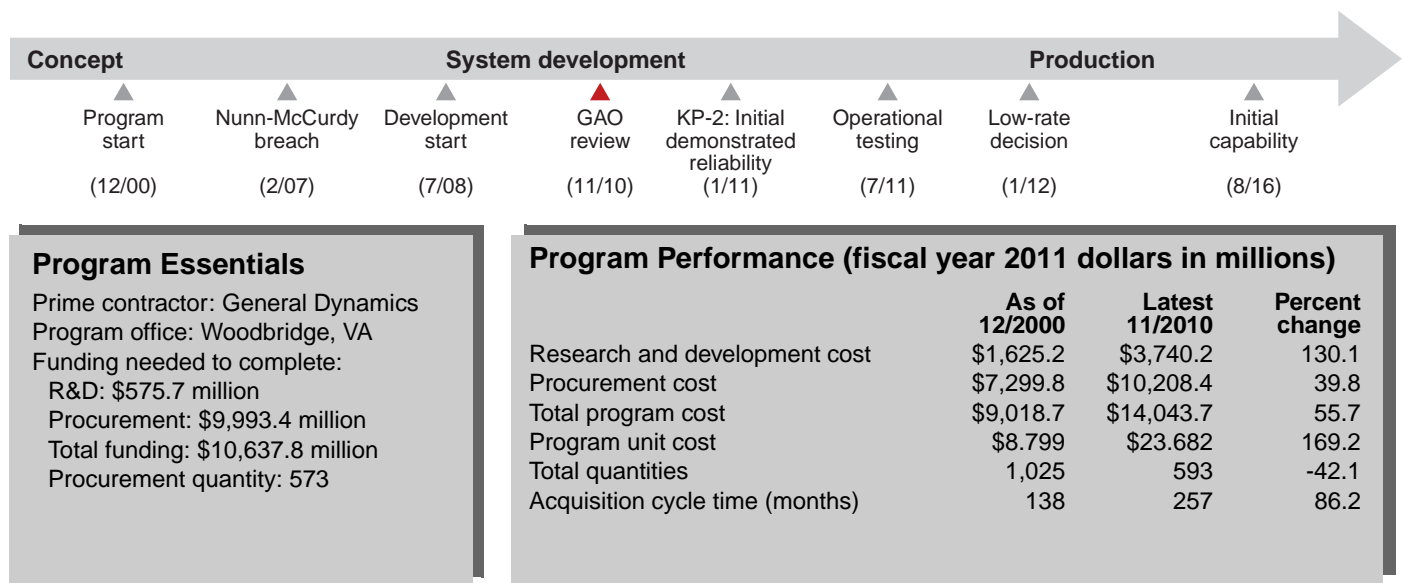
The program office provided technical comments on a draft of this assessment, which were incorporated as appropriate.

## Expeditionary Fighting Vehicle (EFV)

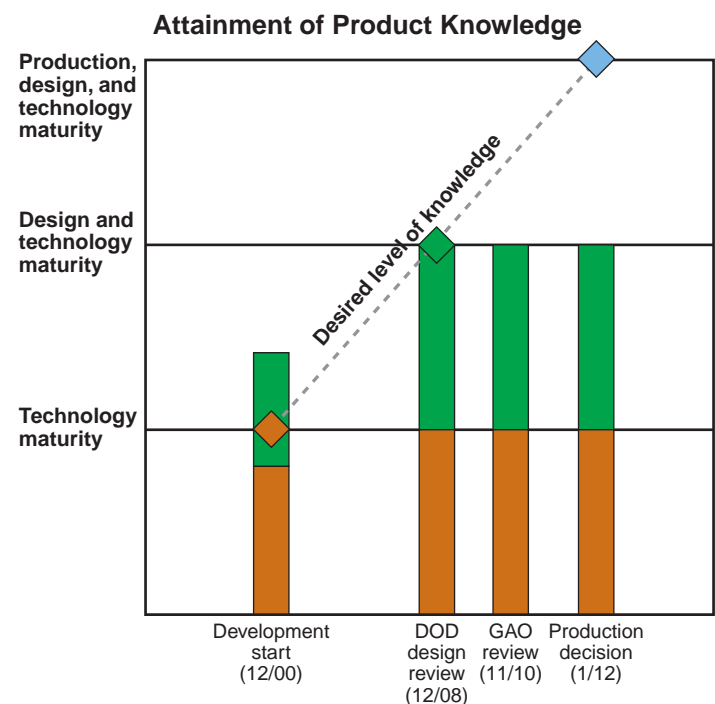
The Marine Corps' EFV is designed to transport troops from ships offshore to inland locales at higher speeds and from longer distances than its predecessor, the Assault Amphibious Vehicle 7A1 (AAV 7A1). The EFV will have two variants—a troop carrier for 17 combat-equipped Marines and 3 crew members and a command vehicle to manage combat operations. Since the program started, DOD has also awarded contracts to redesign key subsystems to improve reliability and to develop an armor kit to protect EFVs from improvised explosive devices.



Source: U.S. Marine Corps.



The EFV's critical technologies are mature, but its design is still evolving. In 2007, DOD extended system development, and the program revised its approach to meeting its reliability requirements. In addition to reliability, the program is monitoring risks related to its schedule, the vehicle's weight, and the potential for increased unit costs. Seven new prototypes, which incorporate significant design changes, are now undergoing development and reliability growth testing, and the program plans to demonstrate the prototypes' initial reliability in January 2011. The Secretary of Defense has proposed canceling the program. If it is not cancelled, the program will determine whether schedule or quantity changes—such as delaying its production decision or reducing initial quantities—are warranted.





## **EFV Program**

### **Technology Maturity**

According to the program office, all four EFV critical technologies—high-pressure jet, high-speed planing, lightweight armor, and power diesel—are mature.

### **Design Maturity**

The EFV's design is still evolving. In 2007, DOD extended system development, and the program revised its approach to meeting its reliability requirements. One part of this approach involved a restructured development effort to test redesigned components on existing prototypes. Another part involved building seven new prototypes, which incorporate 180 significant subsystem design changes to improve the EFV's ability to move, shoot, communicate, and carry and protect troops. The initial reliability goal of the design changes is to increase system reliability from the 4.5 hours mean time between operational mission failures measured in the program's 2006 operational assessment to 16.4 hours prior to the next operational assessment, which is planned for July 2011. The prototypes are now undergoing development and reliability growth testing, and the program plans to demonstrate this 16.4 hour goal in January 2011. The eventual goal is for low-rate initial production vehicles to demonstrate 43.5 hours of reliability during initial operational test and evaluation, which is scheduled to begin in July 2015. These operational test results will support the program's full-rate production decision in September 2016.

### **Production Maturity**

According to the EFV program, it is too early to determine the maturity of the EFV production processes. While the seven developmental prototype vehicles were built using tooling and processes that were representative of those used in production, the program does not intend to collect data on key manufacturing processes or use statistical process controls until low-rate production begins. EFV suppliers are performing inspections of the program's key product characteristics and recording the data in preparation for future statistical process control analysis.

### **Other Program Issues**

The EFV program is entering a period that could determine whether or not it continues. In January 2011, the Secretary of Defense proposed canceling

this program, stating that the EFV would be an enormously capable vehicle if completed, but that the mounting costs of acquiring it needed to be weighed against other priorities.

The program is currently monitoring four risk areas that could affect the ultimate success of the program. Reliability growth has been identified as a risk because there is a chance that the design changes the program has made may not be significant enough to provide the needed improvement in reliability. The program has also identified vehicle weight as a risk. Program officials expect aggressive weight management throughout the current development effort and low-rate initial production to mitigate this risk. While the program's current weight assessment shows that the prototype design will not accommodate the required weight growth for future upgrades and increased loads, the program currently projects that the low-rate initial production design will meet the weight growth margin in the EFV's requirement document for production. The program's schedule leading up to the program's production decision also faces risks. Specifically, technical and software issues could delay key events, such as developmental testing and the start of the program's July 2011 operational assessment. Finally, there is a risk that redesign of the EFV could increase unit costs as well as operations and support costs for the program. If the program continues, it will determine whether schedule or quantity changes—such as delaying its production decision or reducing initial quantities—are warranted to address these risks and its overall affordability.

### **Program Office Comments**

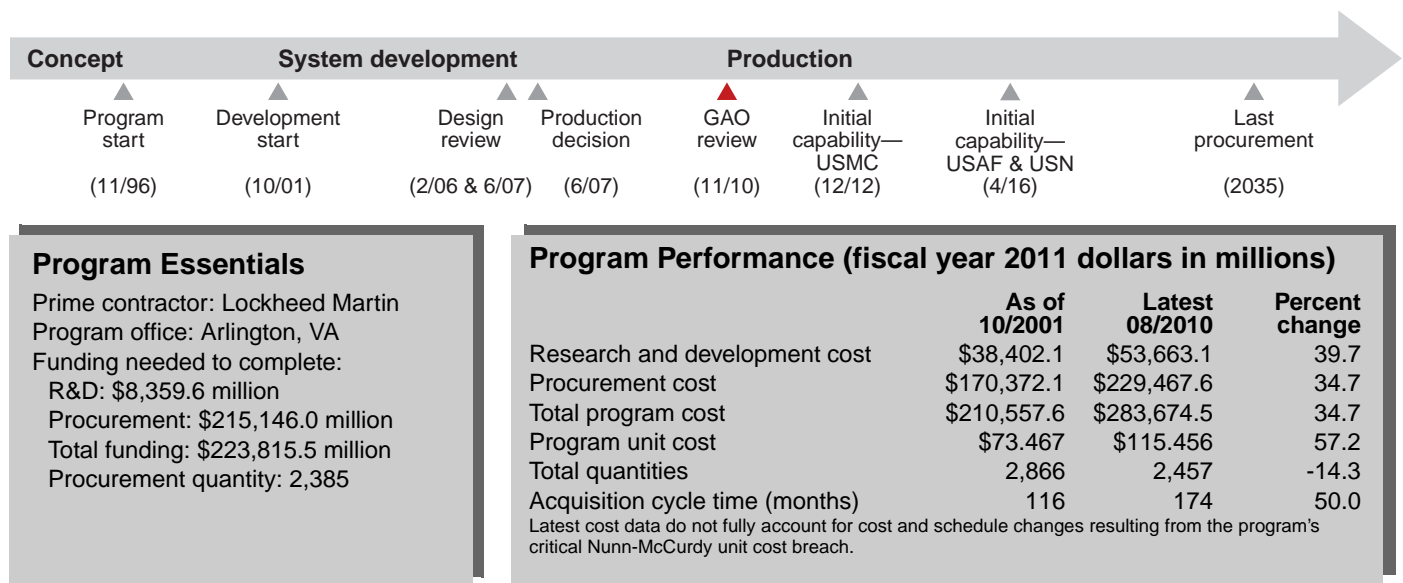
DOD provided technical comments on a draft of this assessment, which we incorporated as appropriate.

## F-35 Lightning II (Joint Strike Fighter)

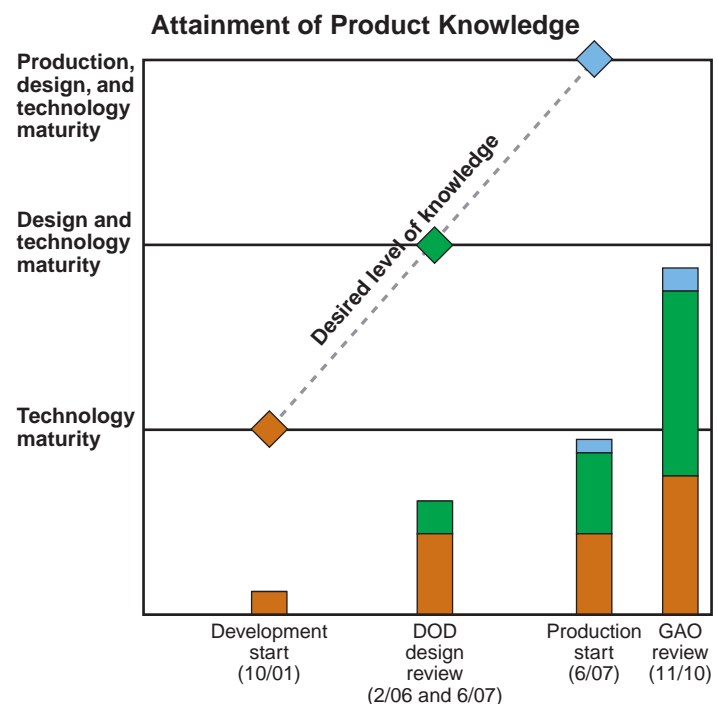
DOD's JSF program is developing a family of stealthy, strike fighter aircraft for the Navy, Air Force, Marine Corps, and U.S. allies, with the goal of maximizing commonality to minimize life-cycle costs. The carrier-suitable variant will complement the Navy F/A-18E/F. The Air Force variant will primarily be an air-to-ground replacement for the F-16 and the A-10, and will complement the F-22. The short take-off and vertical landing variant will replace the Marine Corps F/A-18 and AV-8B aircraft.



Source: 2010 Lockheed Martin.



The JSF is in production but three critical technologies are not mature, manufacturing processes are not proven, and testing is not complete. Continuing manufacturing inefficiencies, parts problems, and technical changes indicate that the aircraft's design and production processes may lack the maturity needed to efficiently produce aircraft at planned rates. With most of developmental and operational flight testing still ahead, the risk of future design changes is significant. DOD restructured the JSF program in February 2010 to address development challenges. The projected cost growth triggered a Nunn-McCurdy unit cost breach of the critical threshold. According to program officials, the JSF is tracking well against its new, less aggressive test schedule despite late deliveries of test aircraft and lower than expected availability rates for short take-off/vertical landing test aircraft.



## **JSF Program**

### **Technology Maturity**

The JSF program entered system development in 2001 with none of its eight critical technologies fully mature. According to the program office, five of these technologies are now mature and three technologies—mission systems integration, prognostics and health management, and radar—are nearing maturity. However, significant development risks remain as the program integrates and tests these technologies.

### **Design Maturity**

The JSF program did not have a stable design at its critical design reviews. The program has now released over 99 percent of its total expected drawings; however, the program continues to experience numerous design changes. With most of developmental and operational flight testing still ahead, the risk of future design changes and their potential effect on the program are significant.

### **Production Maturity**

Despite beginning production in 2006 and procuring 58 aircraft to date, the JSF program's manufacturing processes are still not mature and only 12 percent of its critical processes are in statistical control. DOD has reduced near-term production quantities. However, continuing manufacturing inefficiencies, parts problems, and technical changes indicate that the aircraft's design and production processes may lack the maturity needed to efficiently produce aircraft at planned rates. Managing an extensive, still-maturing global network of suppliers adds another layer of complexity to producing aircraft efficiently and on-time. The prime contractor is implementing manufacturing process improvements. However, due to the extensive amount of testing still to be completed, the program could be required to make alterations to its production processes, changes to its supplier base, and costly retrofits to produced and fielded aircraft, if problems are discovered.

### **Other Program Issues**

After an extensive programwide review, DOD restructured the JSF program in February 2010 to address development challenges. The restructure increased time and funding for system development, added more aircraft to support flight testing, reduced near-term procurement quantities, and

incorporated additional software resources. The projected cost growth—including almost \$104 billion since 2007—triggered a Nunn-McCurdy unit cost breach of the critical threshold. A milestone review was scheduled for November 2010 to update cost and schedule estimates.

According to program officials, the JSF is making progress when measured against its new, less aggressive test schedule and all three variants have had their first flights. However, several issues could affect testing. The program had only delivered eight aircraft to test sites as of December 2010, and short take-off/vertical landing test aircraft have experienced lower than expected availability rates. The program also continues to experience challenges in developing and integrating the very large and complex software requirements needed to achieve JSF capabilities. Further delays in either flight testing or software development could jeopardize the Marine Corps' planned initial operating capability date. Finally, the uncertain fidelity of test results is a risk because the program relies on an unaccredited network of test laboratories and simulation models to evaluate system performance.

### **Program Office Comments**

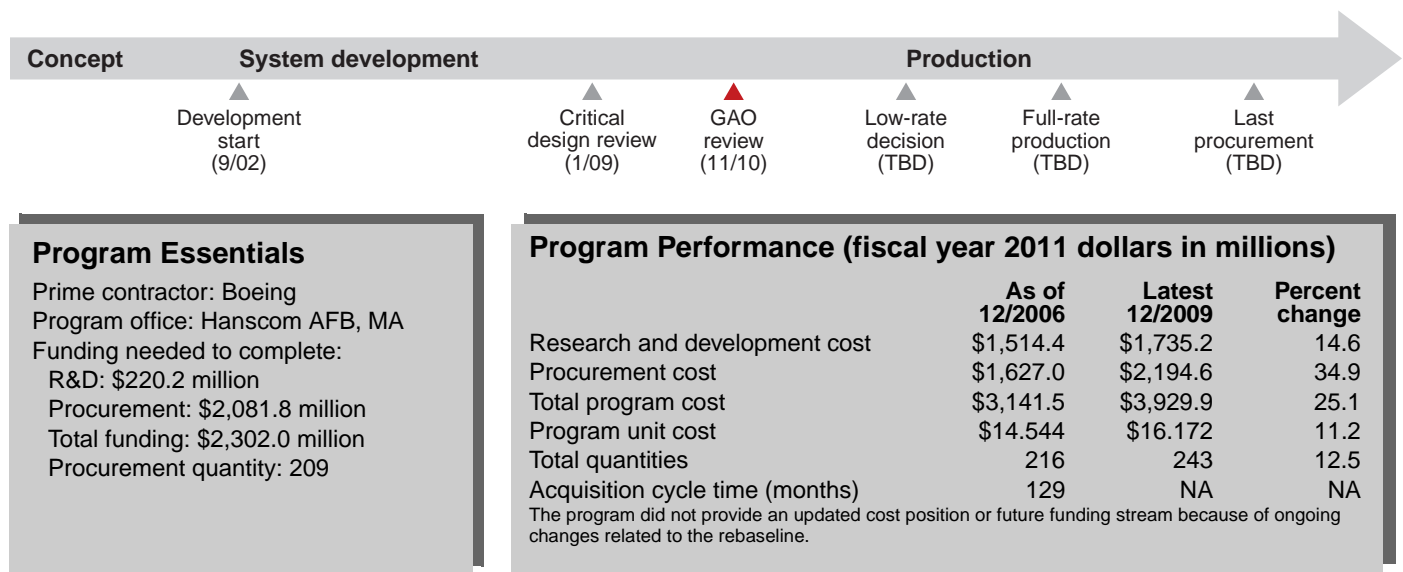
In commenting on a draft of this assessment, the program office noted that JSF is undergoing a technical baseline review of requirements to complete the development effort as part of the consideration for recertification of the development milestone. Eight aircraft of the 10 anticipated in 2010 have been delivered to the test sites. An additional 4 are projected to be delivered by June 2011. The test program has slightly exceeded the overall test flight and test point metrics planned for 2010; testing of the Marine Corps variant is behind plan while testing of the Air Force variant has exceeded plans. Mission systems testing is underway with Block 1.0 on both Air Force and Marine Corps mission systems test aircraft. Over half of the projected airborne system software is in testing including the foundational sensor fusion architecture. Survivability testing has begun (live fire testing and radar cross section signature ground testing) and results thus far are matching predictions. The first airborne dynamic signature test with aircraft AF-3 will begin December 2010.

## Family of Advanced Beyond Line-of-Sight Terminals (FAB-T)

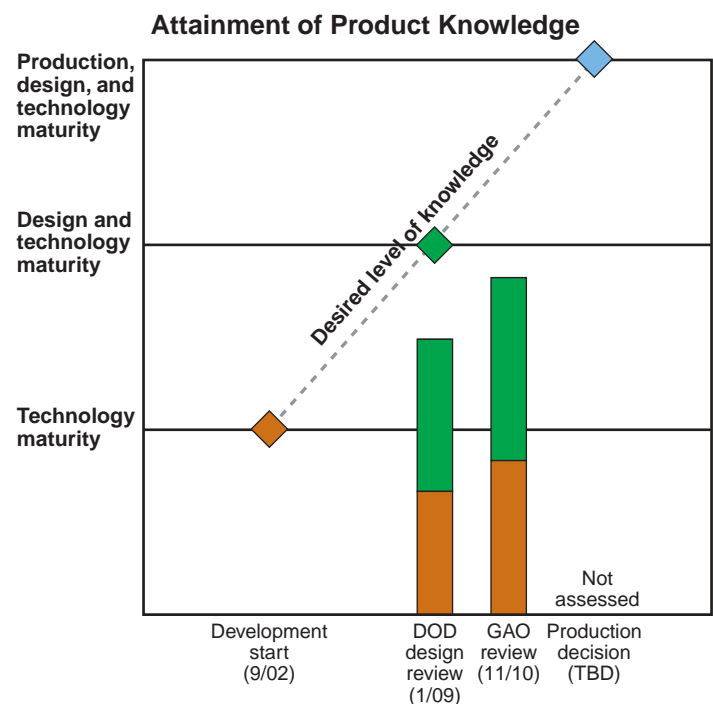
The Air Force's FAB-T will provide a family of satellite communications terminals for airborne and ground-based users. FAB-T will address current and future communications capabilities and technologies, replacing many program-unique terminals. FAB-T is being developed incrementally. The first increment will provide voice and data military satellite communications for nuclear and conventional forces as well as airborne and ground command posts, including the B-2, B-52, RC-135, E-6, and E-4 aircraft. We assessed this increment.



Source: Boeing.



The FAB-T program expected to enter production in February 2010 with its critical technologies mature and its design stable; however, the program now plans to significantly extend its development phase to more fully develop the high-data-rate variant and reduce the concurrency in testing and production. A new low-rate production decision date has not yet been approved, but is tentatively scheduled for the first quarter of fiscal year 2013. Two critical technologies have not yet demonstrated their maturity as planned, and the FAB-T program office continues to monitor certification of the system's cryptography by the National Security Agency. The FAB-T design also does not appear to be stable; however, we were unable to specifically assess it because the program has not provided updated information on its design relating to its restructure and rebaseline efforts.



## **FAB-T Program**

### **Technology Maturity**

The FAB-T program expected to enter production in February 2010 with all six critical technologies mature and demonstrated in a realistic environment. However, according to program officials, two critical technologies—the continuous transverse stub antenna and the high-data-rate software configuration architecture—have not yet demonstrated their maturity as planned. The program has decided to extend the development phase, in large part to more fully develop the high-data-rate software variant. FAB-T's critical technologies were not assessed at development start in 2002 because it was not yet a major defense acquisition program.

### **Design Maturity**

The FAB-T design does not appear to be stable. Even though the program office reported a high percentage of releasable design drawings last year, there have been changes to the program since then that could affect the design. Specifically, as a result of hardware qualification problems and testing failures, the program decided to extend development and delay production. Resolving these issues could require design changes. According to program officials, the program also anticipates that two engineering changes—one related to secure transmissions and another related to environmental specifications—will require additional design work. We were unable to specifically assess the design as a whole because the program has not provided updated information on its design relating to its restructure and rebaseline efforts.

### **Other Program Issues**

The FAB-T program has recently been restructured and rebaselined to more fully develop the high-data-rate variant and reduce concurrency between testing and production. The program delayed its scheduled February 2010 production decision and plans to extend its development phase. In January 2009, the contractor delivered the first FAB-T engineering model. According to program officials, FAB-T completed all the objectives for developmental flight testing of the hardware for the low-data-rate system in August 2009. At that time, program officials expected the extended or high-data-rate system to undergo most of its testing concurrently with low-rate production. However, according to the program

office, hardware qualification problems and testing failures made this level of concurrency an unacceptable risk. The new low-rate production decision date is tentatively scheduled for November 2012. In addition, in response to cost and schedule growth on the FAB-T program, the Office of the Secretary of Defense directed the establishment of four integrated product teams to perform reviews similar to those required for a Nunn-McCurdy breach on management, technical, and cost issues, and to examine potential alternative sources and changes to requirements.

FAB-T certification by the National Security Agency (NSA) is another key step in the program. FAB-T needs to properly protect information at various classification levels and NSA will provide a certification of the cryptography in certain equipment. In June 2009, NSA completed a review of the low-data-rate version of system software and approved limited use of the FAB-T cryptographic element in program testing. Program officials expected to be authorized to test the extended-data-rate version of system software around the end of 2010. The NSA is currently scheduled to complete final certification of this version in March 2013. However, delays in the maturation of the high-data-rate software configuration architecture technology could affect the certification schedule.

### **Program Office Comments**

The Air Force provided technical comments, which were incorporated as appropriate.

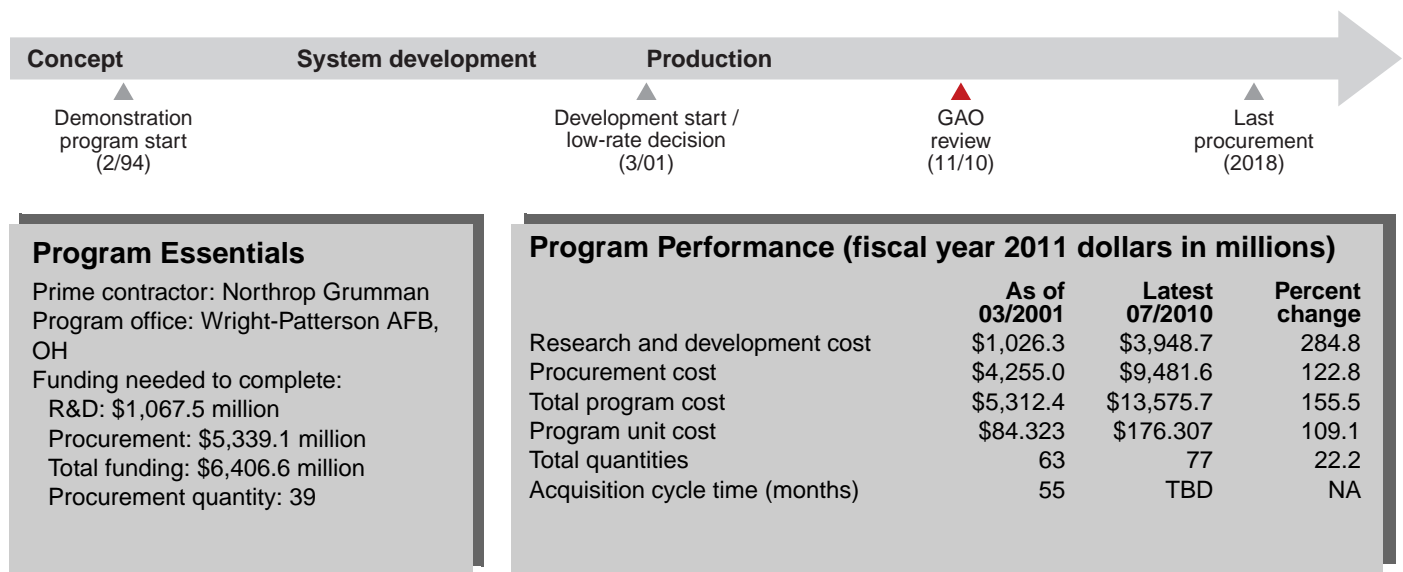


## Global Hawk (RQ-4A/B)

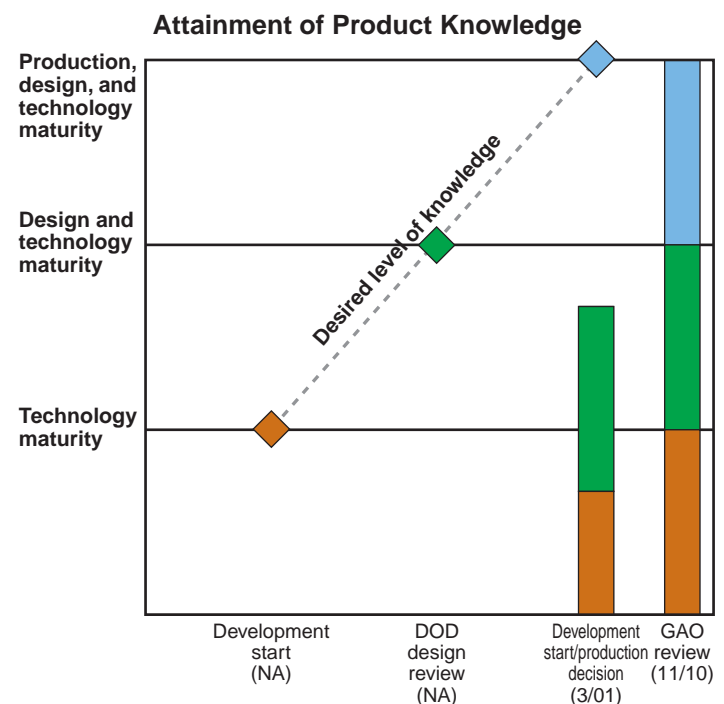
The Air Force's Global Hawk is a high-altitude, long-endurance unmanned aircraft with integrated sensors and ground stations providing intelligence, surveillance, and reconnaissance capabilities. The Global Hawk will replace the U-2. After a successful technology demonstration, the system entered development and limited production in March 2001. The program includes RQ-4A aircraft similar to the original demonstrators, as well as larger and more capable RQ-4Bs. We assessed the RQ-4B, which is being procured in three blocks.



Source: Northrop Grumman.



The Global Hawk RQ-4B has mature critical technologies, a stable design, and proven production processes, but it remains at risk for late design changes and costly retrofits. The completion of operational tests for the aircraft that make up the largest part of the program has been delayed nearly 4 years by testing discoveries, concurrent testing, resource constraints, and weather problems. The program will have procured more than half of those aircraft by the time testing is complete in December 2010. The program also plans to procure more than half the aircraft with advanced radar before it completes operational testing in 2013. The Air Force is taking steps to address some of the testing delays. In fiscal year 2010, the Air Force increased the total number of aircraft to be procured from 54 to 77 and extended planned production through 2018.



## **Global Hawk Program**

### **Technology Maturity**

The critical technologies for the RQ-4B are mature. However, the program must still successfully test two key capabilities—the advanced signals intelligence payload and multiple platform radar—to ensure they perform as expected. The first flight of an RQ-4B equipped with the signals intelligence payload occurred in September 2008 and operational testing is scheduled to be completed in December 2010. After delays in its development, the first flight of an RQ-4B equipped with the multiple platform radar is expected to occur in April 2011. Development testing is underway.

### **Design Maturity**

The RQ-4B basic airframe design is stable with all of its expected design drawings released; however, the program remains at risk for late design changes and costly retrofits if problems are discovered in testing. During the first year of production, frequent substantive engineering changes increased development and airframe costs and delayed deliveries and testing. Substantial commonality between the RQ-4A and RQ-4B had been expected, but as the designs were finalized and production geared up, the design differences were much more extensive and complex than anticipated.

### **Production Maturity**

The manufacturing processes for the RQ-4B airframe are mature and in statistical control. In addition, the program reports that it is meeting its quality goal on the number of nonconforming parts. The RQ-4B aircraft is being produced in three configurations. Block 20 aircraft are equipped with an enhanced imagery intelligence payload; block 30 aircraft have both imagery and signals intelligence payloads; and block 40 aircraft will have an advanced radar surveillance capability. All six block 20 aircraft have been produced. Production continues on block 30 and block 40 aircraft. The first block 30 aircraft was delivered in November 2007 and the first block 40 aircraft was delivered without the sensor in November 2009.

### **Other Program Issues**

The Global Hawk program expects to have procured all of its block 20 aircraft, and more than half of its block 30 and block 40 aircraft before operational testing is complete. As a result, if problems are

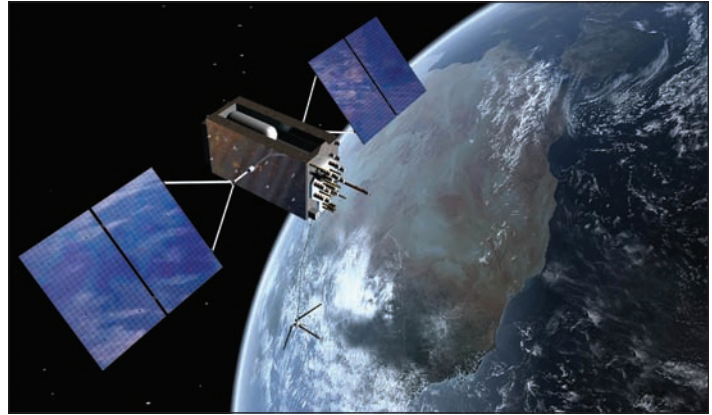
found in operational testing, it could result in costly retrofits for large numbers of aircraft. The Global Hawk program has continued to experience delays in developmental and operational testing. The completion of operational tests for the block 20 and 30 aircraft has been delayed nearly 4 years to December 2010. The start of operational testing for block 40 aircraft has been delayed by more than 3 years to March 2013. According to the Global Hawk's December 2009 Selected Acquisition Report, several factors contributed to the most recent schedule slips, including developmental test discoveries; concurrent development and production testing; testing resource constraints; and weather problems. According to program officials, a shift in focus and resources required to address a Joint Urgent Operational Need, using two block 20 aircraft, has also contributed to block 40 operational test delays. The Air Force is taking steps to address some of the testing delays. For example, the program is now conducting aircraft acceptance tests at Beale Air Force Base in order to free up resources for operational testing at Edwards Air Force Base.

### **Program Office Comments**

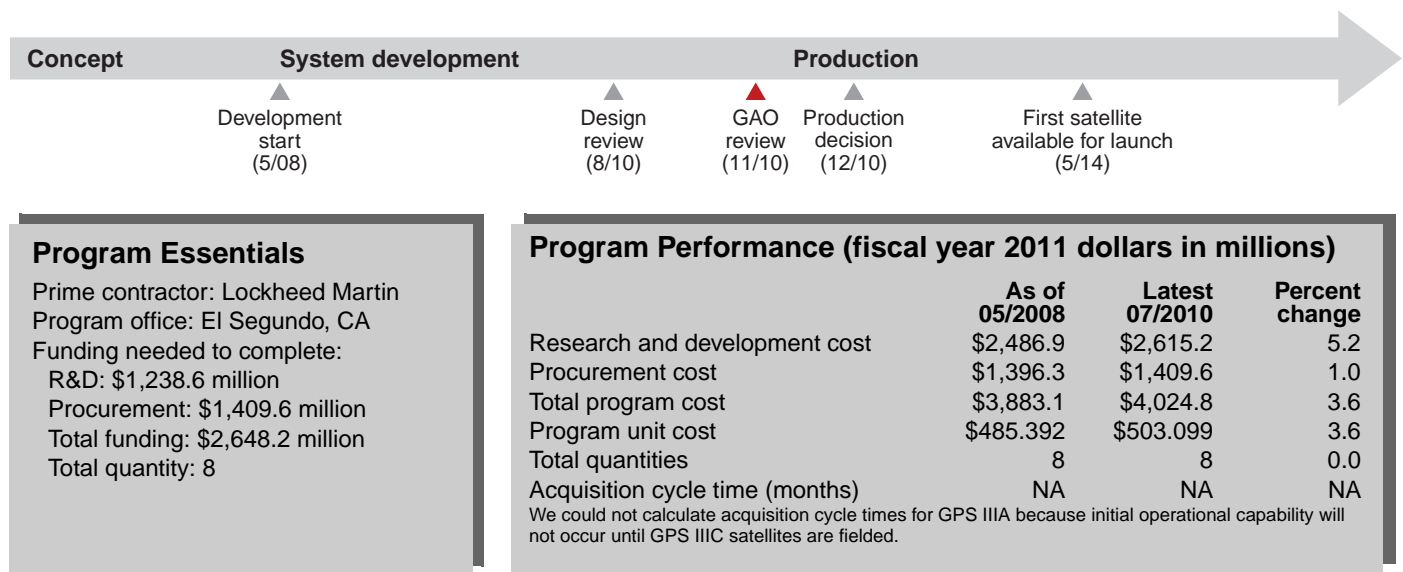
In commenting on a draft of this assessment, the Air Force emphasized that the Global Hawk program has improved program execution while reducing program risk. The Air Force noted that older RQ-4A Global Hawk aircraft—which we did not assess—have been successfully used by the warfighters and other government agencies to carry out various missions. The service also noted that each of the variants of its larger RQ-4B aircraft is now either in operations or testing. Flight operations of deployed aircraft and flight testing of the advanced radar payload are expected to begin in 2011. The Air Force noted that current challenges facing the program include initial system deployments and normalization of operations and sustainment. In addition to commenting on this assessment, the Air Force provided technical comments, which we incorporated where appropriate.

## Global Positioning System (GPS) III A

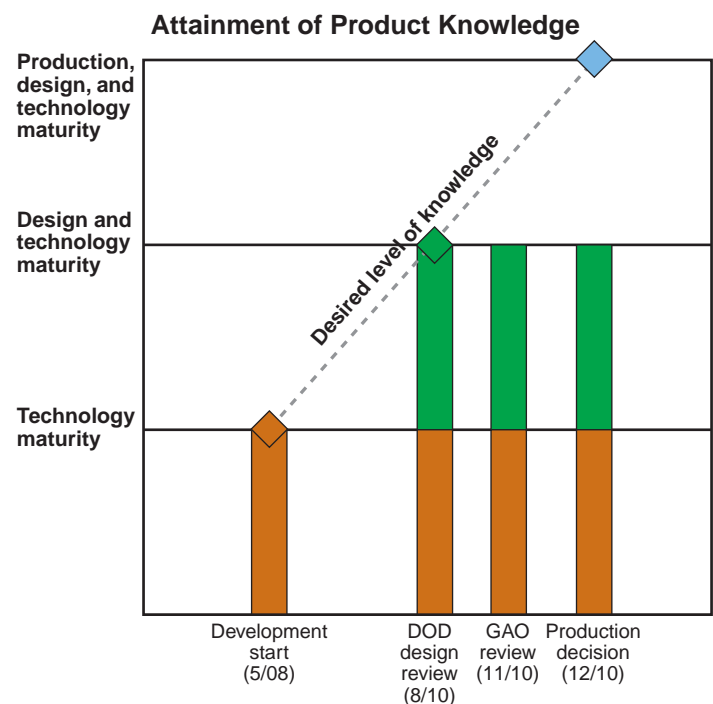
The Air Force's Global Positioning System (GPS) III program will develop and field a new generation of satellites to supplement and eventually replace GPS satellites currently in use. It consists of three increments: IIIA, IIIB, and IIIC. Other programs will develop the ground control system and user equipment. We assessed GPS IIIA, which intends to provide capabilities such as a stronger military navigation signal to improve jamming resistance and a new civilian signal that will be interoperable with foreign satellite navigation systems.



Source: Lockheed Martin.



The GPS IIIA program completed its critical design review in August 2010 with its critical technologies mature and design stable. The program plans to prove its production processes by building and testing a prototype spacecraft prior to its December 2010 production decision. This prototype will include almost all satellite parts excluding redundant units, but will not be flight-worthy. A complete GPS IIIA satellite will not be available for testing prior to the production decision. The GPS IIIA program is using a “back-to-basics” approach, which emphasizes best practices such as maintaining stable requirements and using mature technologies. The program still faces risks to delivering and launching satellites as planned, due to its compressed schedule and dependence on a separately developed ground control system being fully functional.





## **GPS-III A Program**

### **Technology and Design Maturity**

The GPS III A program's critical technologies are mature and its design is stable. The critical technologies have changed for the GPS III A program as it has developed its design. Prior to contract award, the program's five critical technologies were based on a notional government architecture for the satellite. According to the program office, the Lockheed Martin satellite design differs significantly from this architecture. A postpreliminary design review technology readiness assessment in 2009 identified seven critical technologies. However, the number of critical technologies was revised to eight when the results of that assessment were finalized in 2010. All eight have been demonstrated in a relevant environment. According to the program office, the number of critical technologies has been stable as of the postpreliminary design review assessment. In addition, the design for GPS III A is stable with 98 percent of design drawings releasable at its August 2010 critical design review.

### **Production Maturity**

The GPS III A program plans to reduce risk and prove out its production processes by building and testing a prototype spacecraft prior to its December 2010 production decision. However, this prototype will not be production-representative. It will include almost all satellite parts, excluding redundant units. According to the program office, it will not be flight-worthy because its parts will not go through the flight screening process. A complete GPS III A satellite will not be available for testing prior to the production decision. We did not assess production maturity because the program office does not collect statistical process control data for its critical manufacturing processes, but rather uses other process and technology maturity metrics.

### **Other Program Issues**

The GPS III A program has adopted an acquisition approach that should increase its chances of meeting its cost and schedule goals; however, the program still faces risks that could affect the on-time delivery and launch of GPS satellites. GPS III A is being managed using a "back-to-basics" approach, which is designed to maintain stable requirements, implement an incremental development strategy, use mature technologies, and provide more oversight than under the previous GPS satellite program.

While this approach should enable the GPS III program to deliver satellites more quickly than the predecessor GPS program, its schedule is still aggressive considering the complexities associated with the integration phase. The Air Force plans to launch the first GPS III A satellite in 2014. This would require the program to go from contract award to first launch 3.5 years faster than the GPS IIF.

In addition, the GPS III A program could be affected by the development schedule for the next-generation GPS ground control system, the OCX, which is being managed as a separate major defense acquisition program. Though the GPS III A satellites can provide positioning and timing services without OCX, it is needed to control other features of the satellites, such as the enhanced military signal and additional civil signals. Until OCX is operational, these additional signals cannot be operated on the GPS III A satellite, and the Air Force is reluctant to launch the second III A satellite before the first one is fully tested. The Air Force currently plans to deliver GPS OCX Block I in August 2015—15 months after the first planned GPS III A satellite launch.

### **Program Office Comments**

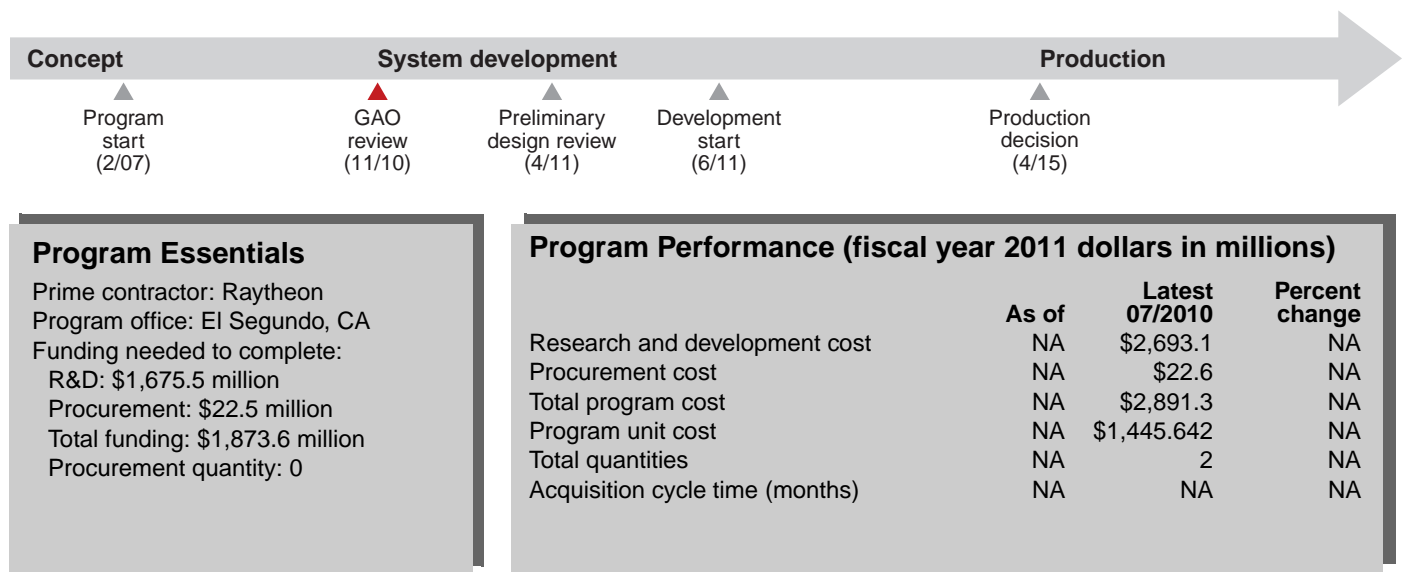
In commenting on a draft of this assessment, GPS program officials acknowledged that there is currently a disconnect between the OCX delivery schedule and the GPS III A launch schedule. As a result, the program office recently awarded a contract to the OCX and GPS III A contractors to study possible technical solutions to provide preliminary ground control capabilities to support the first GPS III A launch. The program expects this interim system to be delivered in the third quarter of 2013. The program officials believe that this system will provide the capability to launch and check out the GPS III A vehicle ahead of OCX completion. Program officials also provided technical comments, which were incorporated as appropriate.

## GPS III OCX Ground Control Segment

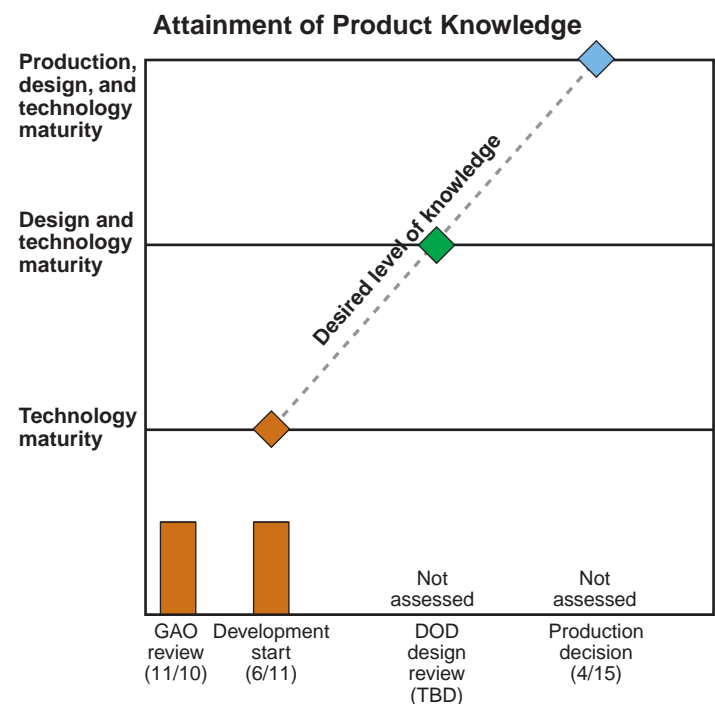
The Air Force's next generation GPS control segment (OCX) will provide command, control, and mission support for the GPS Block II and III satellites. OCX is expected to assure reliable and secure delivery of position and timing signals to serve the evolving needs of GPS military and civilian users. The Air Force plans to develop OCX in four blocks to deliver upgrades as they become available. We assessed the first block, which will support the operations of GPS Block II and Block III satellites.



Source: U.S. Air Force.



The GPS OCX program is scheduled to enter development in June 2011 with its 14 critical technologies nearing maturity. In February 2010, the Air Force awarded a cost-reimbursement contract to Raytheon for Blocks I and II of the OCX program. The GPS OCX program built prototypes and plans to hold a preliminary design review in April 2011 prior to entry into engineering and manufacturing development, as required by DOD acquisition policy and statute. The GPS OCX will not be fielded in time for the May 2014 launch of the first GPS IIIA satellite. As a result, the GPS Directorate is considering funding a parallel effort that accelerates existing launch and checkout requirements to develop a command and control capability for the first GPS IIIA satellites.



## GPS OCX Program

### Technology Maturity

According to program officials, when the GPS OCX enters development in June 2011, its 14 critical technologies will be nearing maturity. As part of its risk-reduction activities, the program selected two contractors, through a competitive process, to develop system-level prototypes. It also plans to hold a preliminary design review in April 2011 prior to entry into engineering and manufacturing development, as required by DOD acquisition policy and statute. In an October 2010 memorandum, the Director, Defense Research and Engineering, stated that an independent assessment of the program found that all but one critical technology had been demonstrated in a relevant environment. The technology that had not been demonstrated in a relevant environment has been deferred to future OCX blocks. The assessment also found that GPS OCX will eventually require larger bandwidths, and questioned whether the backup command and control site will have the capability to take control of all the functions managed by the primary site. Furthermore, the assessment found that the program did not have a security architecture that meets all information assurance requirements, and that the OCX system may not be able to handle large data sets required to service external users. The Director recommended that the Air Force conduct a technology readiness assessment on future OCX blocks to explain how these and any new requirements are fully addressed by mature technologies.

### Other Program Issues

In February 2010, the Air Force awarded a cost-reimbursement contract to Raytheon for Block I and II of the GPS OCX program. According to program officials, a cost-reimbursement contract was used because of the high level of risk associated with developing complex software programs for GPS OCX.

The GPS OCX program plans to enter engineering and manufacturing development in June 2011—over 2 years later than initially planned. According to program officials, this delay was due, in part, to the need to hold a preliminary design review and report on its results before the milestone review. In addition, the GPS Directorate and GPS OCX program manager wanted to make sure that the

program understood the risks associated with the development effort before moving forward to the next phase of the program.

The Air Force plans to deliver GPS OCX Block I in August 2015—15 months after the first planned GPS IIIA satellite launch. To address this issue, the GPS Directorate is considering funding a parallel effort that accelerates existing launch and checkout requirements to develop a command and control capability for the first GPS IIIA satellites. However, GPS Directorate officials indicated that the effort would not enable new capabilities offered by GPS IIIA satellites, including a military signal designed to enable resistance to jamming and three civil signals. The program expects to release a request for proposal for the parallel effort during the first quarter of fiscal year 2011 and receive the Air Force's authority to proceed during the third quarter of fiscal year 2011.

### Program Office Comments

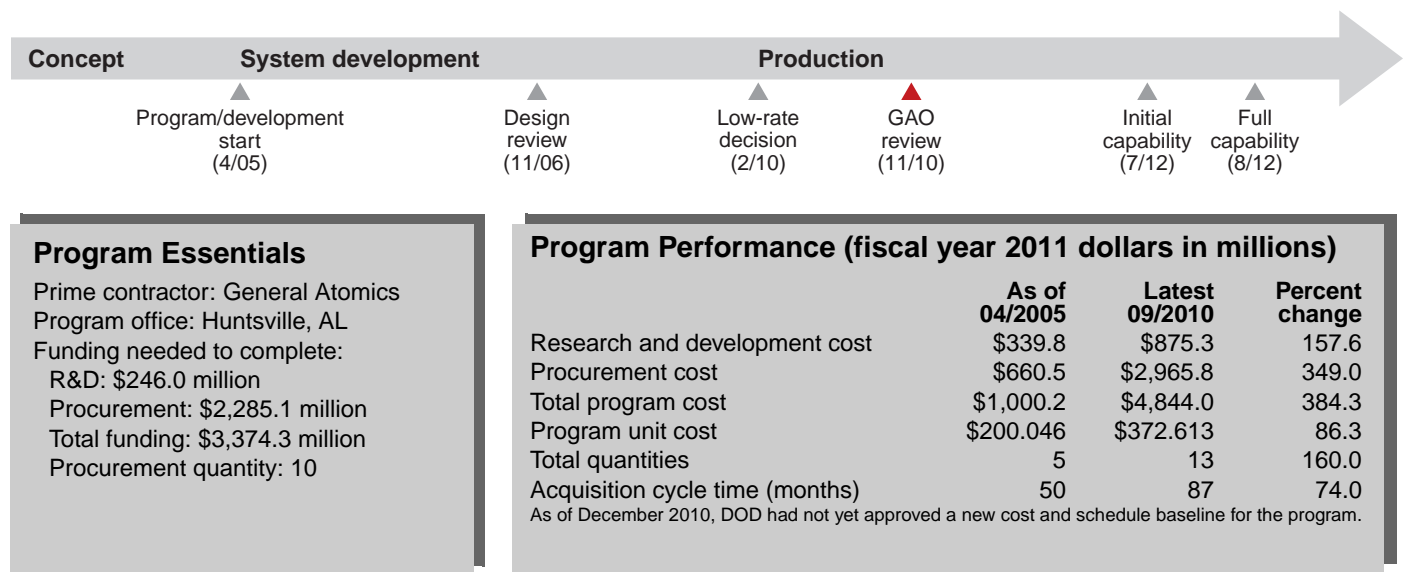
The GPS Directorate provided written technical comments that were incorporated as appropriate.

## Gray Eagle

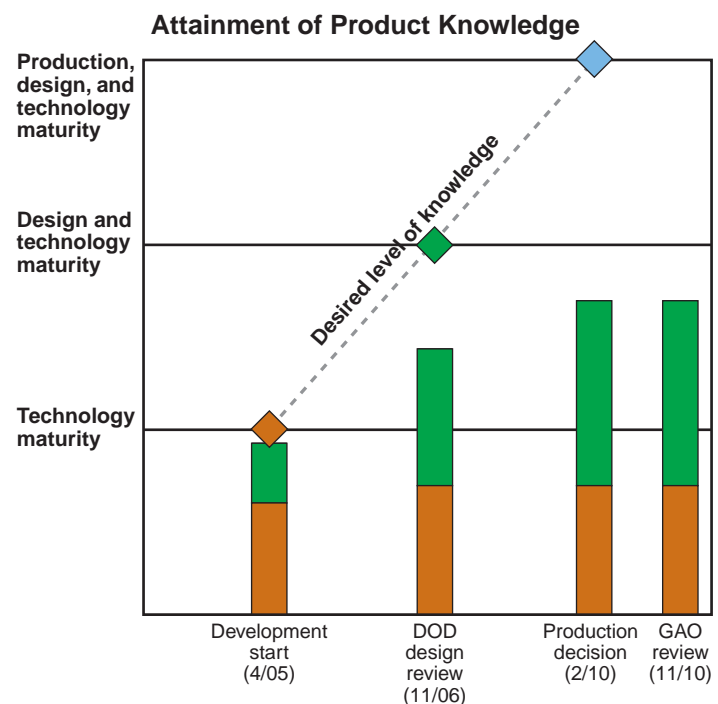
The Army's Gray Eagle, formerly known as ER/MP, will perform reconnaissance, surveillance, target acquisition, and attack missions. It will operate either alone or with other platforms such as the Longbow Apache helicopter. Each system includes 12 aircraft as well as ground control stations, ground and air data terminals, automatic takeoff and landing systems, and ground support equipment. The program consists of Block 1 systems and two less-capable Quick Reaction Capability systems. We assessed the Block 1 configuration.



Source: General Atomics Aeronautical Systems, Inc.



The Gray Eagle entered production in February 2010 without having all of its critical technologies mature. The program office reported that the system's design is stable and its production processes are proven, but the program remains at risk for late and costly design and manufacturing changes during production until its critical technologies have been fully integrated and tested. A January 2010 risk review board identified risks related to areas including software, engine availability, and supplier capacity. The Army has identified operational availability and reliability as a risk after limited user testing showed that the system could not meet its key performance parameter for that area. The Army has plans in place to mitigate these risks and will undertake various risk-reduction activities leading up to the system's entry into initial operational test and evaluation in 2011.



## Gray Eagle Program

### Technology Maturity

The Gray Eagle entered production in February 2010 without all its critical technologies mature, as recommended in DOD's Technology Readiness Assessment Deskbook. Two technologies—the heavy fuel engine and deicing—have been assessed as mature. The other three technologies—the automatic takeoff and landing system, tactical common data link, and manned-unmanned teaming—are nearing maturity.

Prior to 2010, the program office had reported that all its critical technologies would be mature at production. However, an independent technology readiness assessment by the Office of the Director, Defense Research and Engineering, reached a different conclusion on both the identification and maturity level of the program's critical technologies. This assessment resulted in the Army dropping one critical technology, adding two newly identified technologies, and downgrading the maturity level of three technologies. According to the program office, the maturity levels were downgraded because the program office had previously assessed the technologies alone, whereas the independent assessment considered their maturity when integrated with Gray Eagle. For example, the program office had assessed the automatic takeoff and landing system as mature because the same technology is used on the already-fielded Shadow unmanned aircraft system, but the independent assessors rated it as nearing maturity because the system had not yet been fully integrated into the Gray Eagle and tested in an operational environment.

### Design Maturity

While the program office indicated that the Gray Eagle design is stable, the program remains at risk for late and costly design and manufacturing changes during production until its critical technologies have been fully integrated and tested. Despite this risk, the Army plans to proceed with production. In 2009, the Army's Aviation and Missile Research, Development, and Engineering Center independently assessed the program's production readiness and concluded that the design of the system was mature and stable enough such that potential design changes would not present a significant risk to the program during low-rate initial production.

### Production Maturity

According to an independent Army assessment of the program's production readiness, for critical or major suppliers, its manufacturing process maturity was satisfactory and manufacturing infrastructure met or exceeded requirements for low-rate initial production. However, in January 2010, an Army review board noted production risks associated with the tactical common data link subcontractor's capacity to produce, provide spares for, and repair that component as needed to meet program schedule. In addition, it identified issues with software development and engine availability resulting from issues with financial stability of the engine supplier. According to the program office, the data link production capacity issue has been largely mitigated and the prime contractor has qualified a second engine supplier.

### Other Program Issues

In October 2010, the Army identified operational availability and reliability as a risk after limited user testing showed that the system could not meet its key performance parameter for that area. The Army plans to undertake risk-reduction activities leading up to the system's initial operational test and evaluation in 2011.

### Program Office Comments

In commenting on a draft of the assessment, the program office indicated that the DOD Technology Readiness Assessment Deskbook discourages the practice of evaluating technology readiness based on degree of integration. The program also believes that our product knowledge graph did not accurately capture the Gray Eagle's production maturity because there are more methods to assess maturity than the critical processes assessment we used. The program did not detail the methods it believed applicable. Finally, the program stated that all risk-mitigation plans were on schedule as of January 2011. The program also provided technical corrections, which were incorporated as appropriate.

### GAO Response

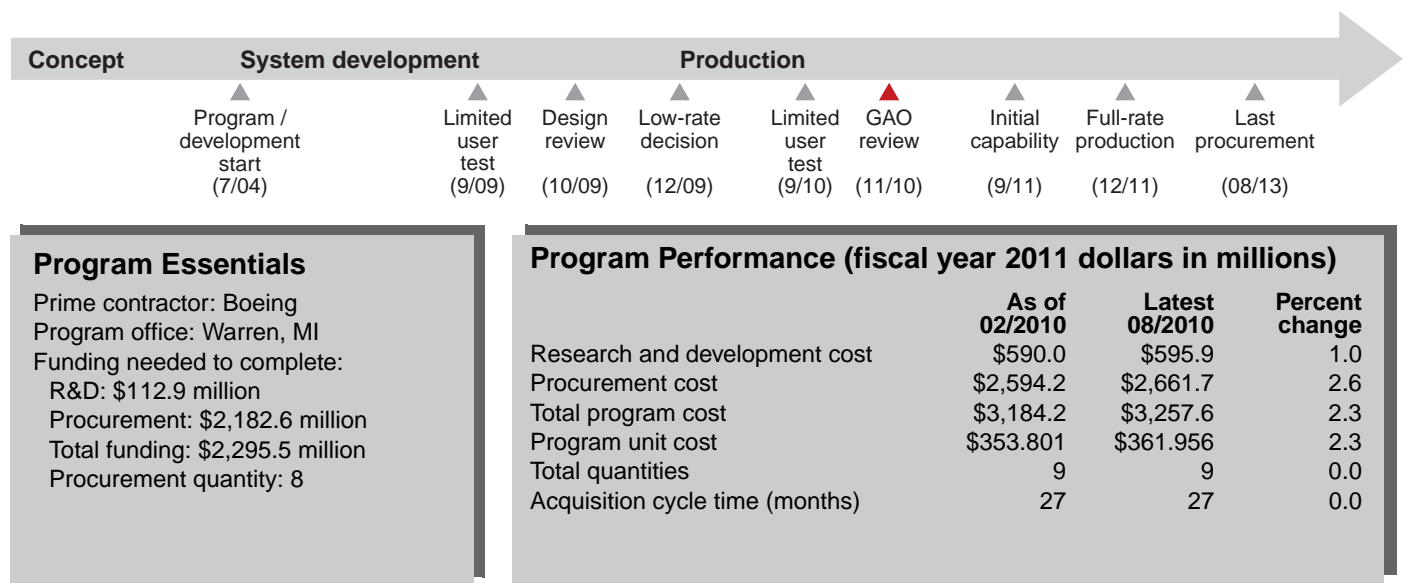
According to the DOD deskbook, technologies should be at technology readiness level (TRL) 7 or higher at production start. To achieve TRL 7, a program should demonstrate a system prototype in an operational environment, which would require them to be integrated in the system.

## Increment 1 Early-Infantry Brigade Combat Team (E-IBCT)

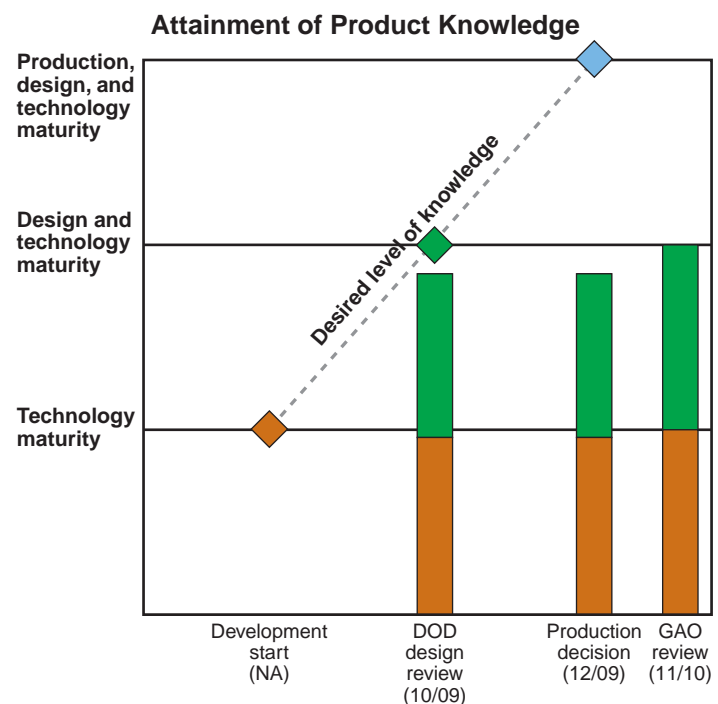
The Army's E-IBCT program will augment brigade-level capabilities through an incremental, expedited fielding of systems to current forces. The first increment, scheduled for fielding in late 2011, includes unattended sensors, unmanned ground and air vehicles, and new radios and battle command software. Increment 1 evolved from Army efforts to quickly equip current forces with the more mature capabilities from the now terminated Future Combat System program. The Army anticipates at least one follow-on increment.



Source: U.S. Army.



E-IBCT Increment 1 was approved for production in December 2009, even though an independent review team later found that none of its critical technologies were mature, and the program was still making design changes to address reliability issues identified in testing. Since that time, the Army has worked to improve performance and reliability of the E-IBCT systems. According to the Army, all current Increment 1 critical technologies are mature and its systems' designs are stable. The results of an updated independent technology assessment were not available at the time of our review. In addition, the Army was unable to provide production data from the contractor. The Under Secretary of Defense for Acquisition, Technology and Logistics was scheduled to review the program in December 2010 to determine whether to proceed with the production of the next two sets of systems.





## **Increment 1 E-IBCT Program**

### **Technology Maturity**

According to the Army, all current E-IBCT Increment 1 critical technologies are mature, although independent reviewers disagree. Prior to the December 2009 production decision, the Army reported that 9 out of 10 critical technologies were mature. However, a March 2010 independent assessment reported that none of the critical technologies were mature and only two technologies were nearing maturity. The assessment found that the Army had not demonstrated two key radio technologies under the expected operational conditions or at the required range. It also found that other technologies displayed erratic performance, experienced excessive reboots, or were relatively primitive with regard to efficiency and robustness. According to Army officials, a September 2010 limited user test planned to demonstrate the improved maturity of these technologies. To support the Under Secretary of Defense for Acquisition, Technology and Logistics' December 2010 review of the program, the Director, Defense Research and Engineering, planned to complete an updated independent technology assessment. The results of that assessment were not available at the time of our review.

### **Design Maturity**

According to the Army, the designs of the E-IBCT Increment 1 systems are stable with 93 percent of the total expected design drawings releasable to manufacturing. These designs were not stable when the program received approval to enter production in December 2009. The program has made 86 design changes since then to address performance and reliability issues. These design changes were incorporated into the equipment that was used in a September 2010 limited user test and into the systems' production configuration.

### **Production Maturity**

We did not assess production maturity because the Army was unable to provide statistical process control data on critical manufacturing processes. However, Army documents indicate that the systems have achieved an engineering manufacturing readiness level of 3, which demonstrates readiness for low-rate production.

### **Other Program Issues**

The Under Secretary of Defense for Acquisition, Technology and Logistics was scheduled to review the program in December 2010 to consider the systems' readiness for further testing and fielding, whether to proceed with additional production, and the direction for the remainder of the program. The review was to be based on the Army's progress improving the systems' reliability and network performance during the September 2010 limited user test.

During tests leading up to the September 2010 limited user test, the Army reported that only one system failed to meet its reliability requirement for entrance into the limited user test. However, an Army assessment of the 2010 limited user test reported that only three of the five systems met or exceeded reliability requirements. Although reliability did improve since the 2009 limited user test, the systems were collectively assessed as not providing force effectiveness at the system of systems level and, with the exception of the small unmanned ground vehicle, provided minimal military utility.

### **Program Office Comments**

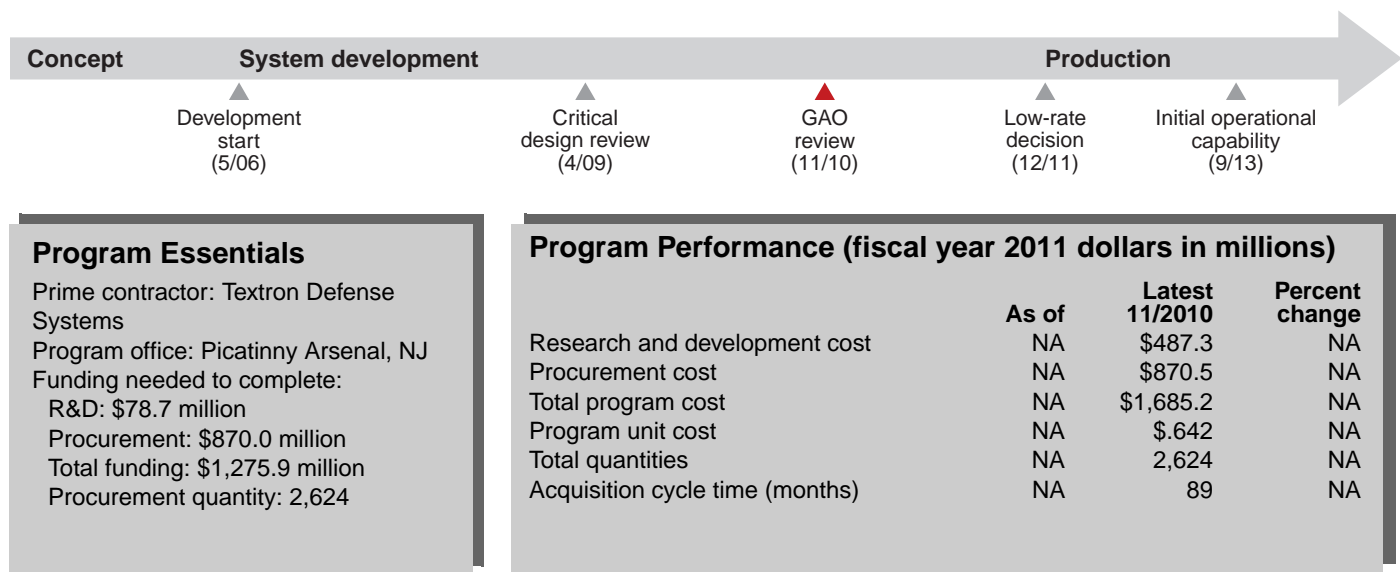
According to the program office, in 2009, significant concerns were raised regarding the reliability of Increment 1 systems and network maturity. Testing conducted in 2010 demonstrated significant reliability improvements with all systems (less the unmanned aerial system) greatly exceeding their reliability requirements. Testing also proved network maturity for the E-IBCT configuration and the Network Integration Kit was determined to be a key command and control enabler. The Training and Doctrine Command identified two key issues with the Network Integration Kit, and the program manager has already implemented and demonstrated fixes. The Training and Doctrine Command has voiced strong support for the Network Integration Kit and Small Unmanned Ground Vehicle. On the basis of a December 2010 Army Configuration Steering Board and a pending Defense Acquisition Board, a descoping of systems and quantities is expected. Cost and quantity information for the anticipated changes are predecisional and were not made available for this report. The Army provided additional technical comments, which were incorporated as appropriate.

## Intelligent Munitions System-Scorpion

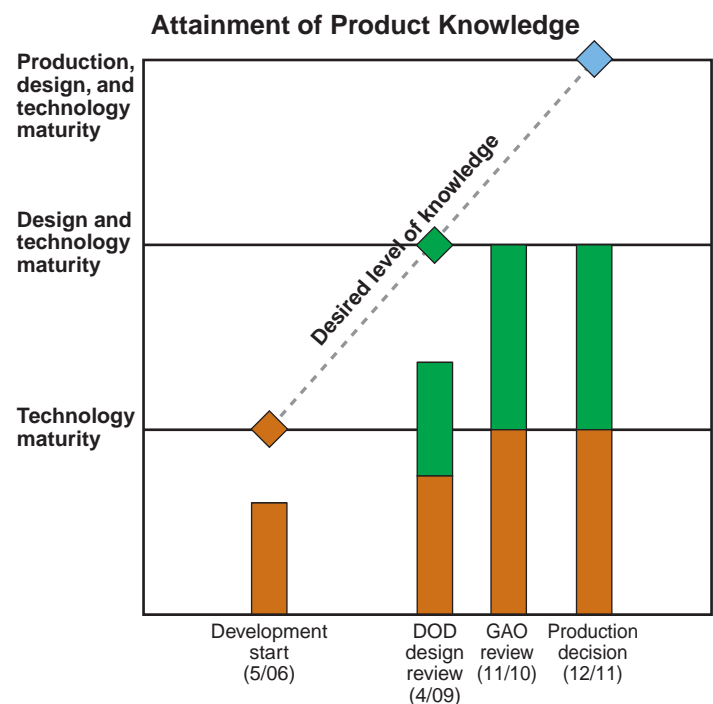
The Army's Intelligent Munitions System-Scorpion is a remotely controlled, antivehicular landmine alternative system. The Scorpion includes an integrated system of lethal and nonlethal munitions, sensors, software, and communications that detects, tracks, classifies, reports, engages, and kills light wheeled through heavy tracked vehicles. As part of the Army's capability portfolio review, it was determined that the Scorpion is no longer affordable. Program closeout was approved by a configuration steering board in October 2010.



Source: U.S. Army.



The Scorpion program's critical technologies are mature and its design is stable. The program initially planned to use the Joint Tactical Radio System, but has switched to the more mature Spider radio. While the Scorpion's design was not stable at its April 2009 design review, over 90 percent of its design drawings are now releasable and its critical software functionality has been tested. The program will conduct a series of production readiness reviews as it prepares for its December 2011 production decision. In addition, the program is already producing test hardware on the production floor using production processes, personnel, and tooling. Originally part of the Future Combat System, the program was established as a stand-alone program in January 2007. The separation caused cost growth which led to the program being designated a major defense acquisition program in February 2010.





## Scorpion Program

### Technology Maturity

All four of the Scorpion's critical technologies—the control station computing unit, situational awareness, antivehicle effects, and communications through Spider radio—are mature. When the program began development in 2006, its critical technologies included the Joint Tactical Radio System (JTRS) Cluster 5 radio and the JTRS Network Enterprise Domain soldier radio waveform. As a result of differences between the Scorpion and JTRS development schedules, the program switched to the mature Spider radio.

### Design Maturity

The Scorpion's design has stabilized since its April 2009 design review when only 61 percent of its total expected drawings were releasable. Over 90 percent of its design drawings are now releasable and its safety-critical and major software functionality has been tested. While risk-reduction tests completed in November 2009 have demonstrated the capability of the system's design utilizing production-representative hardware, the system's poor performance against heavy tracked vehicles and another required target is a design concern. According to the program's January 2010 post-critical design review assessment, the Army needs to make a decision on the importance of this requirement because the program is utilizing resources to try to meet it and it could affect the system's overall performance. In addition, the assessment identified system reliability and an aggressive program schedule as challenges.

### Production Maturity

We could not assess production maturity because the program does not collect statistical process control data on its critical manufacturing processes; however, the program has taken a number of steps to prepare for its planned December 2011 production decision. The program has identified its critical manufacturing processes and key product characteristics and uses yield and defect data and defect management to track them. According to the program office, the contractor began identifying and developing custom tooling and test equipment that would be required for production shortly after development start. Production processes and tooling were refined during this period and utilized in the next phase wherein operations personnel built

hardware with engineering oversight. All Scorpion hardware delivered for qualification testing has been produced on the production floor, using production processes, personnel, tooling, and special test equipment. The program will also conduct a series of production readiness reviews to support the transition to production.

### Other Program Issues

The Scorpion began development as part of the Future Combat System (FCS) program in 2006. It supports the National Landmine Policy announced in February 2004, which stated the United States would no longer use non-self-destructing antivehicle and antipersonnel landmines after December 31, 2010. In January 2007, the Army separated the Scorpion program from the FCS. In February 2010, due to development cost growth, which was attributed to negative effects from the separation and technical issues during development, the Scorpion program was designated as a major defense acquisition program.

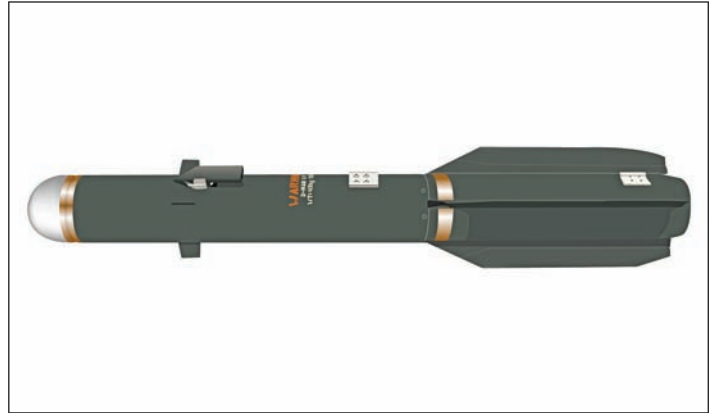
As part of the Army's capability portfolio reviews, it was determined that the Scorpion is no longer affordable and that the Army is willing to accept the operational risk of not fielding this capability. However, some of this technology will roll into the Spider program. The decision to conduct an orderly closeout was approved by a configuration steering board in October 2010 and the official acquisition decision memorandum is pending.

### Program Office Comments

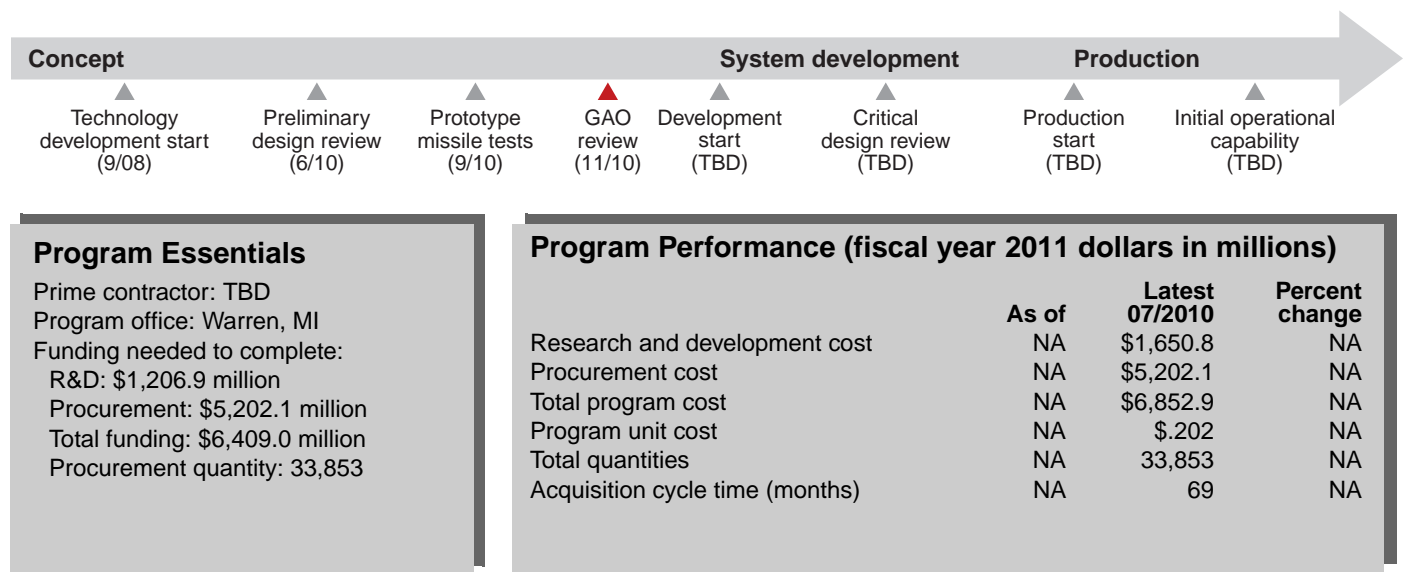
The Scorpion program was developed to avoid a capability gap associated with the National Landmine Policy and field a capability prior to December 31, 2010. Due to this pressure, the program was initially schedule driven. Following the critical design review, the program plan was updated to reflect an event driven schedule. Following the risk-reduction testing in November 2009, design changes and modifications to the requirement improved performance against the heavy tracked vehicles, and changes to the tactics, techniques, and procedures by the engineer school resulted in improved performance against lightwheeled vehicles. These enhancements were demonstrated during conduct of development and live fire testing in September 2010. Program officials also provided technical comments, which were incorporated as appropriate.

## Joint Air-to-Ground Missile (JAGM)

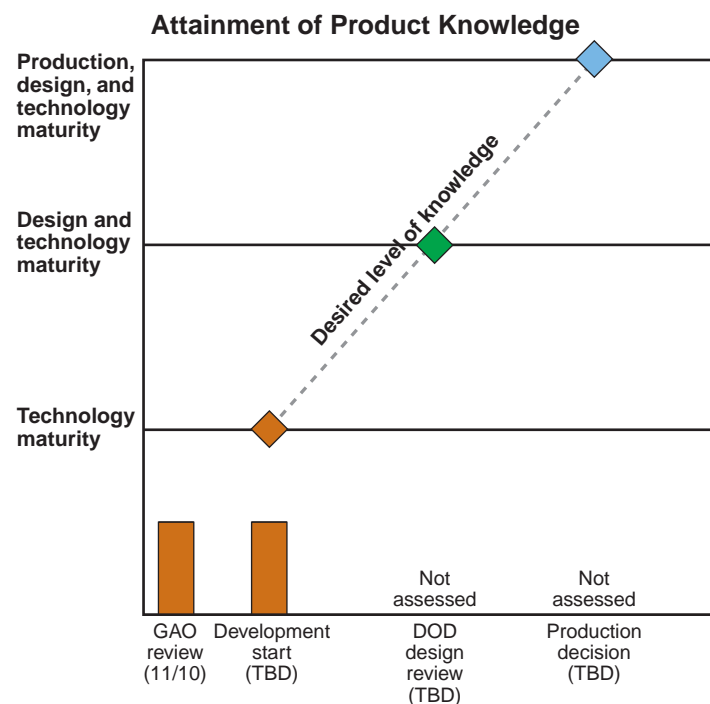
The Joint Air-to-Ground Missile is a joint Army/Navy program with Marine Corps participation. The missile will be air-launched from helicopters and fixed-wing aircraft and designed to target tanks; light armored vehicles; missile launchers; command, control, and communications vehicles; bunkers; and buildings. It is to provide line-of-sight and beyond line-of-sight capabilities and can be employed in a fire-and-forget mode or a precision attack mode. The missile will replace Hellfire, Maverick, and air-launched TOW.



Source: Department of Defense.



According to the program office, the three JAGM critical technologies are expected to be nearing maturity and demonstrated in a relevant environment before a decision is made to enter development. However, an independent technology readiness assessment identified five critical technologies, at least one of which has not reached this level of maturity. The program office has incorporated a provision in the draft request for proposal for the development contract that may mitigate some of the technology risk by requiring both contractors to submit two rocket motor designs. According to program officials, the release of the request for proposal has been delayed until the third quarter of fiscal year 2011 because the program's acquisition strategy and requirements needed to be updated to reflect the cancellation of the Armed Reconnaissance Helicopter and new guidance on affordability.



## JAGM Program

### Technology Maturity

According to the program office, the three JAGM critical technologies are expected to be nearing maturity and demonstrated in a relevant environment before a decision is made to start system development. The critical technologies include a multimode seeker for increased countermeasure resistance, boost-sustain propulsion for increased standoff range, and a multipurpose warhead for increased lethality. However, an independent technology readiness assessment identified five critical technologies, at least one of which has not reached this level of maturity. The program office has incorporated a provision in the draft request for proposal for the engineering and manufacturing development contract that may mitigate some of the technology risk by requiring both contractors to submit two rocket motor designs.

### Other Program Issues

In September 2008, the Army awarded two fixed-price incentive contracts to Raytheon and Lockheed Martin for a 27-month JAGM technology development phase. During technology development, each contractor completed three tests using prototype missiles in order for the program to assess the technical risks of proceeding to the next phase of development. In addition to testing prototypes, each contractor completed a preliminary design review. According to program officials, a post-preliminary design review assessment should be complete by December 2010.

The JAGM program planned to receive approval to enter system development in November 2010 and award an engineering and manufacturing development contract in December 2010. However, the release of the request for proposal for this contract has been delayed because the program's acquisition strategy and requirements needed to be updated to reflect the cancellation of the Armed Reconnaissance Helicopter, the addition of the OH-58 Kiowa as a replacement platform, and new guidance on affordability. According to program officials, contract award is now expected no earlier than the third quarter of fiscal year 2011. The JAGM program office has requested a justification and approval for a limited competition for the

engineering and manufacturing development contract between the two technology development contractors.

The Army and the Navy will continue to rely on Hellfire and Maverick missiles until JAGM is fielded. The Army will continue to extend the fielding of Hellfire to meet the needs of the warfighter, while the Navy will rely on both Maverick and Hellfire until JAGM becomes available.

### Program Office Comments

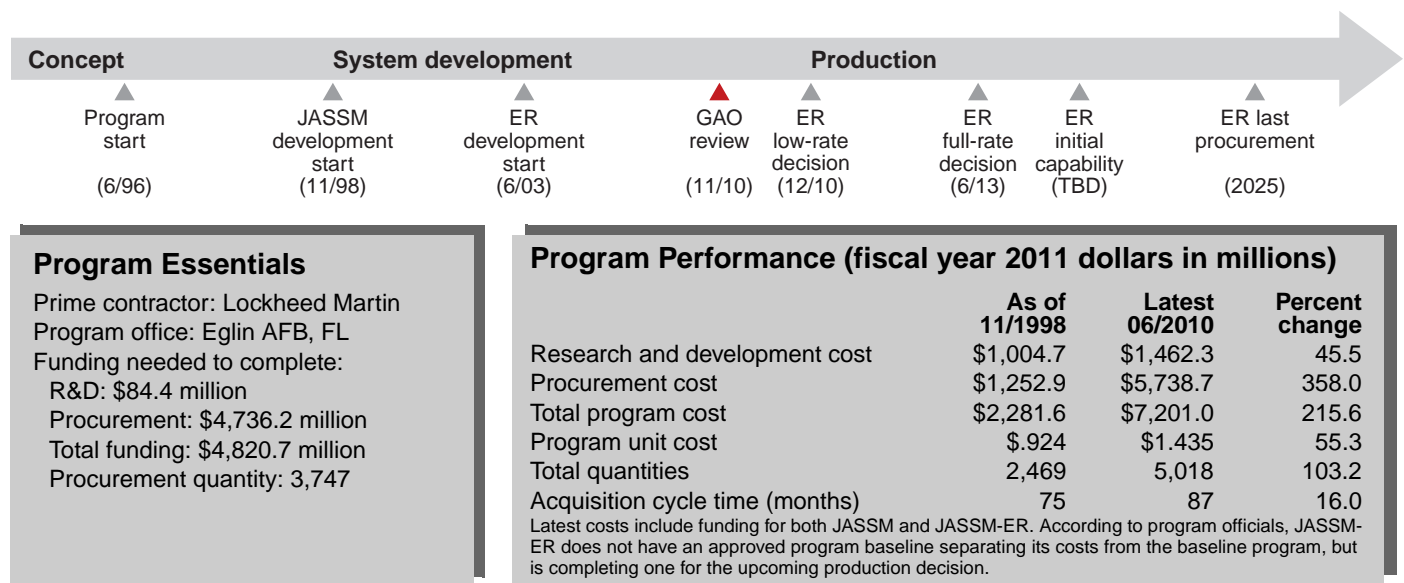
In commenting on a draft of this assessment, the program office stated that due to the delay in the signing of the JAGM acquisition strategy, key dates in the development phase have the potential to be delayed.

## Joint Air-to-Surface Standoff Missile (JASSM)

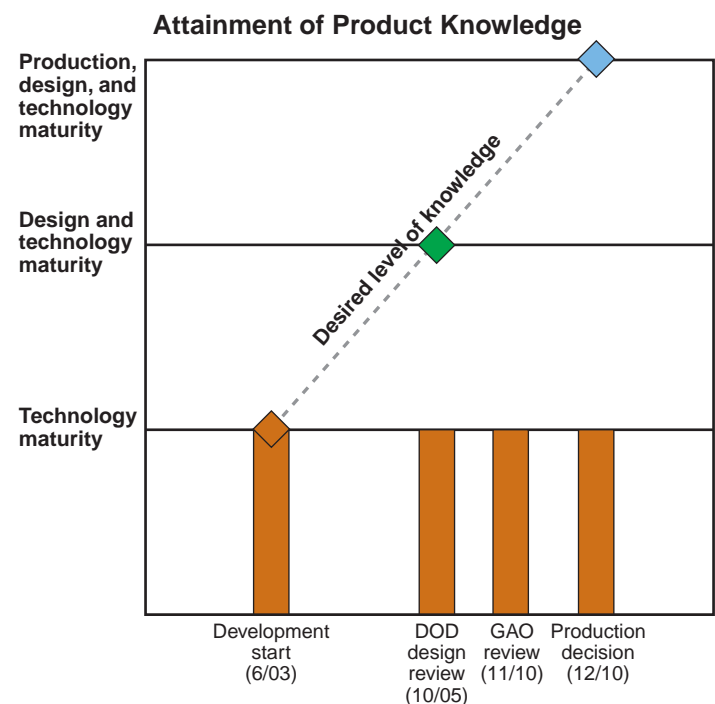
The Air Force's JASSM program is intended to field a next-generation air-to-ground cruise missile capable of stealthy flight and reliable performance at affordable costs. It is designed to destroy enemy targets from outside the range of air defenses. The Air Force is currently producing a baseline JASSM and is developing an extended range version—JASSM-ER—that will more than double the range of the baseline version. The two variants are 70 percent common in hardware and 95 percent common in software. We assessed the JASSM-ER variant.



Source: U.S. Air Force.



According to the program office, the JASSM-ER plans to enter production in December 2010 with all of its critical technologies and manufacturing processes mature. We did not assess the design stability of the JASSM-ER because the program office does not collect design drawing data. However, the JASSM-ER design has been demonstrated to perform as intended. It has been successful in 10 out of 11 flight tests. The program plans to perform additional tests in order to demonstrate that it meets its reliability requirement. As part of the upcoming production decision, the program has assessed its manufacturing readiness and proven out manufacturing and quality processes in a pilot-line environment. The cost of the JASSM-ER could be higher than predicted because prior cost estimates were overly optimistic and flight tests will be needed to achieve its reliability requirement.



## **JASSM Program**

### **Technology Maturity**

An independent review panel recently assessed all five JASSM-ER critical technologies as mature. The five technologies are the engine system, engine lube system, fuse, low-observable features, and global positioning system. This assessment was conducted to support the upcoming JASSM-ER production decision.

### **Design Maturity**

According to the program office, the JASSM-ER design is stable. The design has been demonstrated to perform as intended and the missile has been successful in 10 out of 11 flight tests. However, we did not specifically assess design stability because the JASSM-ER program office does not track the number of design drawings. According to the program office, under the total system performance responsibility arrangement that was in place when the program was initiated, all design drawings were developed and managed by the contractor. The Air Force has since sought more control over the design of the missile. It now has approval authority over major configuration changes, as well as approval authority over configuration changes that may increase cost, require retrofit, or affect safety for missiles currently in production.

### **Production Maturity**

According to a program official, the JASSM-ER plans to enter production in December 2010 with all of its manufacturing processes mature. The Air Force recently assessed JASSM-ER at a manufacturing readiness level 8, meaning, among other things, that its technologies are mature, manufacturing and quality processes and procedures have been proven in a pilot-line environment, and it is ready to enter into low-rate production. In addition, the JASSM-ER missiles are being produced on the same production line as the JASSM baseline, and the two missiles are 70 percent common in hardware and 95 percent common in software.

### **Other Program Issues**

The cost of the JASSM-ER program could be higher than predicted. First, lower than projected annual procurement levels could increase production costs. The Air Force's current cost estimate for the JASSM program may be overly optimistic since it is based on a production rate of 280 missiles per year

(combined JASSM and JASSM-ER production rate), which has not been achieved since 2005. Not producing at the expected rate has led to a less efficient production process and a longer production period, both of which increase costs. Further, Lockheed Martin officials stated that low production rates could cause skilled labor to look elsewhere for work and JASSM reliability could be adversely affected. In addition, according to the Air Force, as many as 20 flight tests may be needed to fully demonstrate JASSM-ER's reliability goal of 85 percent. These flight tests could cost as much as \$70 million.

### **Program Office Comments**

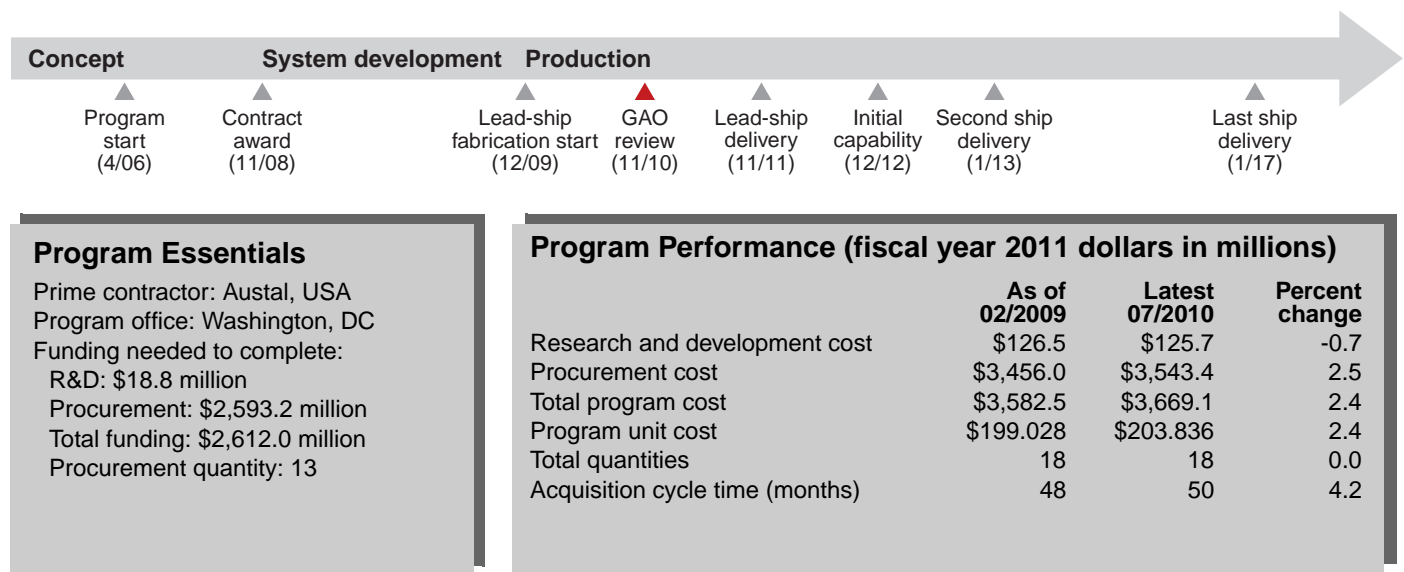
In commenting on a draft of this assessment, the JASSM program office noted the reliability concerns have been alleviated by successful tests of JASSM-ER (10 of 11, completed November 2010) and Lot 7 JASSM baseline (15 of 16, completed October 2009). Additional flight tests beyond the budgeted operational test and reliability assessment programs are not required to achieve the reliability requirement of 85 percent following JASSM-ER Lot 4. In fact, JASSM-ER is currently at 87 percent at the conclusion of developmental tests. The risk for higher JASSM-ER costs stems from unforeseen budget cuts that reduce production quantities and drive up unit price. Additionally, the JASSM-ER design is stable as evidenced by the last five flight tests flown with the current production configuration, and the program's successful completion of a production readiness review. The JASSM program also provided technical comments, which were incorporated where appropriate.

## Joint High Speed Vessel (JHSV)

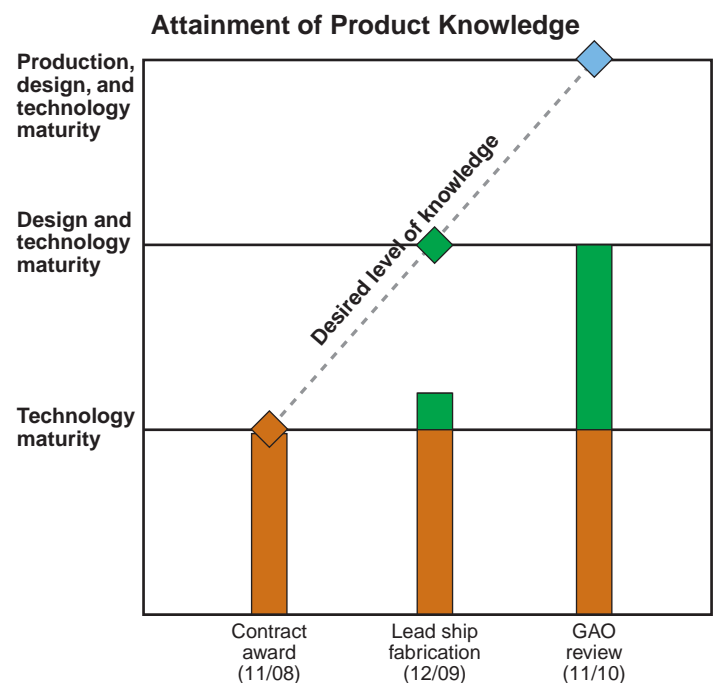
The JHSV is a joint Army and Navy program to acquire a high-speed, shallow-draft vessel for rapid intratheater transport of combat-ready units. The ship will be capable of operating without reliance on shore based infrastructure. The program intends to produce a total of 18 ships, 13 for the Navy, and 5 for the Army. DOD authorized construction of the lead ship in December 2009. It is expected to be delivered in November 2011.



Source: Austal USA.



The JHSV program entered production in December 2009 with its critical technologies mature, but without a complete three dimensional design. Nine of the ship's 46 design zones were complete in the three-dimensional model when construction began. According to the Navy's own measure of design maturity—which takes into account other design metrics such as completeness of two-dimensional design drawings and engineering reviews, as well as the three-dimensional model—the design was at least 85 percent complete. Program officials state that the three-dimensional model was completed in September 2010. As of October 2010, 33 modules were in production utilizing instructions derived from the model. Prior to starting production, DOD agreed to reduce the JHSV's required transit speed, in order to avoid the need for a significant redesign that could have affected the program's cost and schedule.





## JHSV Program

### Technology and Design Maturity

The JHSV program awarded its detailed design and construction contract in November 2008 with 17 of its 18 critical technologies mature and demonstrated in a realistic environment. Before production began in December 2009, the program was required to demonstrate that all technologies were mature.

In December 2009, DOD authorized the Navy to begin construction of the lead ship without a complete three-dimensional design. According to program officials, 9 of the ship's 46 three-dimensional design zones were complete at the start of construction. An additional 14 design zones were nearing completion. According to program officials, construction start was delayed 34 days to complete product modeling for the JHSV's most complex areas, such as the ship's machinery rooms. This level of design maturity falls short of GAO's recommended shipbuilding best practices, which call for achieving a complete and stable three-dimensional product model before construction begins. The program office believes that the completion of the model prior to construction start was less critical for JHSV because it is not as complex as other Navy ships, such as the DDG 1000. According to the Navy's own measure of design maturity—which includes the completion of two-dimensional design drawings and engineering reviews as well as the three-dimensional model—the design was at least 85 percent complete. According to program officials, the three-dimensional model was completed in September 2010.

### Production Maturity

Prior to the start of production, the JHSV program was required to demonstrate that its manufacturing processes were in control. The program conducted two pilot production phases and built a pilot module in the shipbuilder's new module manufacturing facility. According to program officials, production will be monitored through the use of earned value management data to track the cost of the work performed, and through reviews and inspections performed by the American Bureau of Shipbuilding and the Navy's Supervisor of Shipbuilding. As of October 2010, the program office reported that 33 of the ship's modules were in production.

### Other Program Issues

DOD chose the JHSV to participate in the capital budget account pilot program, which was created to control cost growth by providing stable funding. Under this initiative, the program office must gain approval from the Joint Chiefs of Staff, the Office of the Under Secretary of Defense for Acquisition, Technology and Logistics, and the Office of the Under Secretary of Defense (Comptroller) for changes in funding or requirements. Program officials stated that this is useful as it allows them to stabilize their requirements and the flow of work to the shipyard. Funding for 10 of the program's 18 ships is currently guaranteed.

Prior to starting production, DOD agreed to reduce the JHSV's required transit speed, to avoid design changes that could have affected the program's cost and schedule. Previously JHSV had been required to have a transit range of 4,700 nautical miles traveling at a speed of 25 knots. According to program officials, transiting at this speed requires additional amounts of fuel that would have triggered the need for a significant redesign, cost increases, and schedule delays. As a part of a configuration steering board meeting, officials from the JHSV Navy requirements office, Joint Staff, and DOD agreed that the speed could be reduced to 23 knots to preserve the current design and schedule with minimal effect on meeting mission needs.

### Program Office Comments

The program office did not concur with our findings related to design maturity. As certified by Navy and Defense Department officials, per Public Law 110-181, greater than 85 percent of the design was completed prior to construction start by the Navy's measure of design maturity. In addition, the three-dimensional model was completed prior to the start of fabrication of the future USS Vigilant, the first JHSV, on September 13, 2010. Significant production and financial risk has been avoided by using proven commercial production design and technology, ensuring stable requirements, minimizing change, and through the ruthless pursuit of cost reduction and efficiency.

### GAO Response

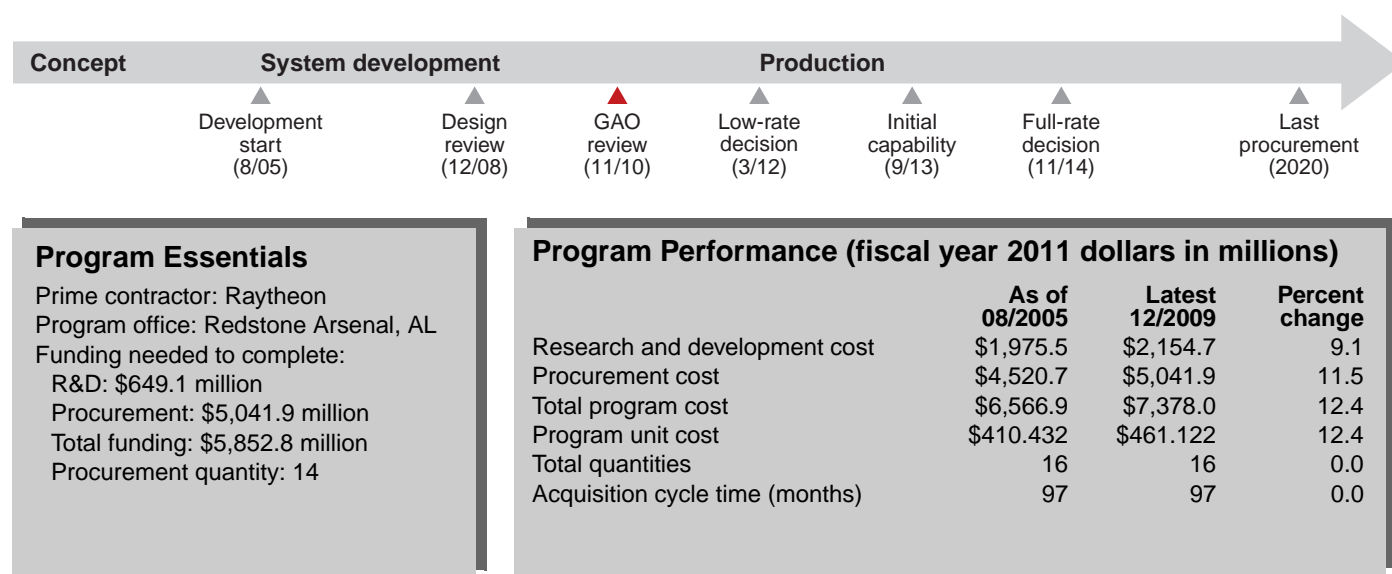
Our findings on the design maturity of the JHSV are based on metrics determined by previous audits of Navy shipbuilding programs and commercial best practices.

## Joint Land Attack Cruise Missile Defense Elevated Netted Sensor System (JLENS)

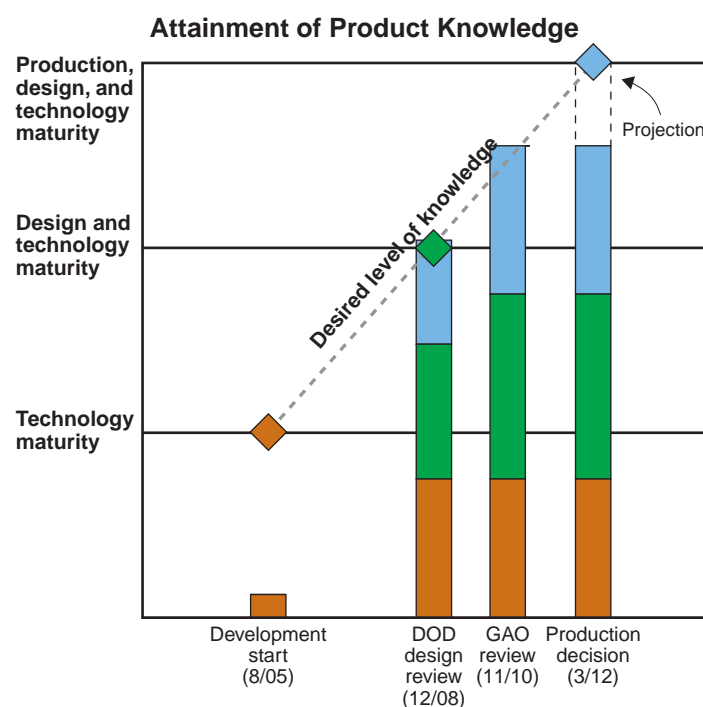
The Army's JLENS will provide over-the-horizon detection and tracking of land-attack cruise missiles and other targets. The Army is developing JLENS in two spirals. Spiral 1 is complete and served as a test bed to demonstrate the concept. Spiral 2 will utilize two aerostats with advanced sensors for surveillance and tracking, as well as mobile mooring stations, communication payloads, and processing stations. JLENS will provide surveillance and engagement support to other systems, such as PAC-3, SM-6, and MEADS. We assessed Spiral 2.



Source: U.S. Army.



According to program officials, JLENS will enter production with mature technologies, a stable design, and proven production processes. The program began development in 2005 with only one of its five critical technologies mature, and only two of the four current critical technologies are mature. The design appears stable, but the potential for design changes remains until the maturity of JLENS components have been demonstrated. In September 2010, an aerostat accident resulted in the loss of one of the JLENS platforms. This accident and other system integration challenges are expected to delay several key program events, including the production decision. Twelve of the program's 15 critical manufacturing processes are currently in control. The JLENS program has also completed a number of key production planning activities, such as assessing supplier capabilities and risks.





## **JLENS Program**

### **Technology Maturity**

JLENS entered system development in August 2005 with only one of its five critical technologies mature. The program subsequently combined two of the critical technologies—the communications payload and the processing group—into the communications processing group. The communications processing group and platform are currently mature. The program expects to demonstrate the fire control radar and surveillance radar in a realistic environment before the program enters production. Many of the JLENS radar technologies have legacy components. However, sensor software items related to signal processing, timing, and control, as well as element measurement, are not yet mature. The program office has successfully conducted tests of the fire control radar antenna, but the integration of both the fire control radar and surveillance radar components in the program's system integration laboratory has yet to occur.

### **Design Maturity**

The JLENS design appears stable, but the potential for design changes will remain until key JLENS components have been integrated and tested. For example, a first flight demonstration of the aerostat was successfully conducted in August 2009, but the program must still complete a series of tests integrating the JLENS mobile mooring station with the aerostat. In September 2010, the program experienced the loss of a platform following an aerostat accident. The program is analyzing the cause of the accident, as well as other system integration issues. The JLENS program has received approval to transport the mobile mooring station without armor, which mitigates a risk the program office has identified in the past.

### **Production Maturity**

The JLENS program projects that it will enter production with all 15 of its critical manufacturing processes mature and stable. According to the program office, 12 of the program's critical manufacturing processes are currently in control. The JLENS program has also completed a number of key activities that are essential to effective production management, including updating its manufacturing plan and addressing areas such as supplier capabilities and risks, cost, quality control, materials, producibility, and workforce skills.

### **Other Program Issues**

The JLENS program is working to address several risks that could affect the program's cost, schedule, and performance. First, the program received \$32 million less than the amount requested in the President's fiscal year 2010 budget. If additional funding is not provided in fiscal year 2012, the program reports it will not be able to procure the equipment to field an initial operational capability by the end of fiscal year 2013. Second, due to the September 2010 aerostat accident and subsequent loss of a platform, the program expects several key events, including the start of production, to be delayed. Third, if problems occur during systems integration and verification tests, the program expects that cost and schedule would be affected. Fourth, if test site preparations are not complete by April 2011, then the production timeline could be jeopardized. Finally, the program could also be affected by alignment with the Army's Integrated Air and Missile Defense program. As part of the integrated strategy, the Army extended the system development and demonstration phase by 12 months. The JLENS program is waiting approval of a new acquisition program baseline with updated cost and schedule estimates that reflect this change.

### **Program Office Comments**

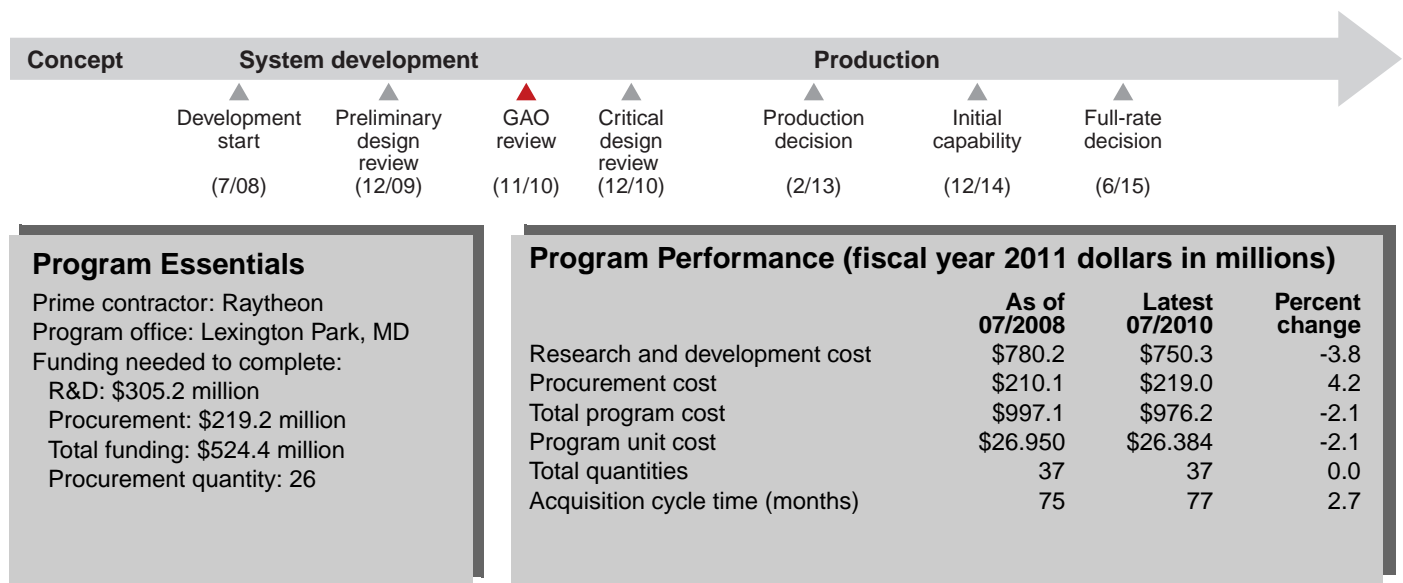
In commenting on a draft of this assessment, the program stated that the Army is planning to request funds in its fiscal year 2012 budget to offset the fiscal year 2010 reduction. The program also reported experiencing development challenges that have caused system integration delays, and schedule challenges due to a September 2010 aerostat accident. The program office continues to work on a new acquisition program baseline. A new cost estimate was presented to the Army Cost Review Board in July 2009. The estimate will be updated based on the results of an Army review and submission of the President's fiscal year 2012 budget. A revised baseline is expected to be approved in the third quarter of fiscal year 2011. The Army provided technical comments, which were incorporated as appropriate.

## Joint Precision Approach and Landing System (JPALS)

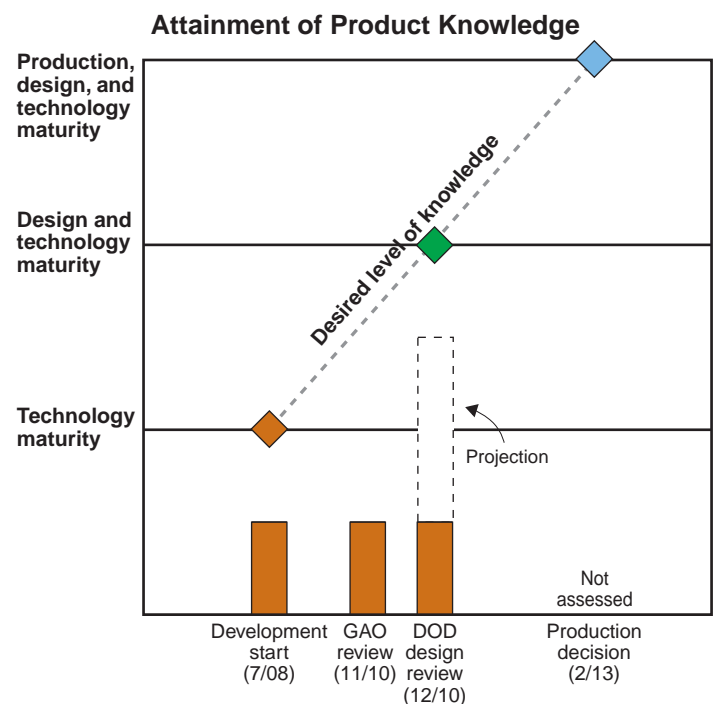
JPALS is a joint Army, Navy, and Air Force program that will replace the obsolete radar-based SPN-46 and SPN-35 systems. It is a Global Positioning System/Inertial Navigation System-based system that will provide a rapidly deployable, adverse weather, adverse terrain, day-night precision approach and landing capability for all DOD ground and airborne systems. Increment 1A is a Navy-led sea-based ship system, and increment 1B will integrate JPALS with sea-based aircraft. We assessed increment 1A.



Source: Department of Defense.



JPALS began system development in July 2008 with both of its critical technologies nearing maturity. JPALS is primarily a software development effort but also includes commercial hardware components. The hardware design is stable and program officials accepted the system's drawings in preparation for the December 2010 critical design review. However, design stability has been affected by requirements changes. As of January 2011, there were 387 requirements in the system performance specification—an increase of 33 since the start of development. Officials also report ship integration challenges on CVN 78 may require changing the antenna placement to accommodate performance and maintenance requirements. The program plans to enter production in 2013. Increment 1B will begin development in 2012 and integrate the system with the avionics of the F/A-18E/F, EA-18G, and MH-60R/S.



## JPALS Program

### Technology Maturity

The JPALS program began development in July 2008 with two critical technologies—the geometry extra redundant almost fixed solution and the vertical protection level / lateral protection level—nearing maturity. Program officials expect both critical technologies to be mature and demonstrated in a realistic environment by the JPALS production decision in 2013. While JPALS utilizes existing commercial components for most of its hardware, its functionality will be enabled by over 700,000 lines of software code. The program plans to rely heavily on reused code with 77 percent of the program's total lines of code expected to be reused. If less software is reused than originally estimated, the potential consequences are longer development time and greater cost.

### Design Maturity

JPALS is primarily a software development effort, but also includes commercial hardware components. The hardware design is stable with 96 percent of the total expected design drawings released to manufacturing. The drawings cover the JPALS ship system-radio, antenna, receiver, racks, and console. The program also tracks requirement changes to monitor design stability. As of January 2011, there were 387 requirements in the system performance specification—an increase of 33 since the start of development. These changes are due to system design gaps uncovered for L-class ships, the Joint Strike Fighter, and legacy landing systems and updated maintenance requirements. According to program officials, detailed software requirements are stable and proceeding according to schedule to support software development. The first of seven software blocks is complete and blocks 2 and 3 are on schedule.

### Production Maturity

Program officials plan to employ various techniques to assess production maturity, including tool design, fabrication metrics, and quarterly production readiness reviews. The program will build eight engineering development models to be installed on aircraft carriers and sent to test facilities to demonstrate system performance. These models are expected to be delivered in fiscal years 2011 through 2012. The program plans to enter production in February 2013.

### Other Program Issues

According to program officials, several ship integration challenges are being addressed. Specifically, the current JPALS antenna location for the JPALS system on CVN 78 affects the program's ability to meet performance and maintenance requirements. Trade studies are investigating several potential antenna location changes to determine the optimal position for it. The cost effect of moving the antenna will not be known until the studies are complete. Program officials also continue to monitor the system's maintainability to ensure JPALS requires no manpower increase compared to legacy systems—a key performance parameter. JPALS has completed a detailed maintenance analysis, the results of which indicate that the estimated workload meets this manpower requirement. JPALS is also at risk of exceeding its weight limit for CVN 78. It currently exceeds the requirement by 500 pounds. The program office reported that CVN 78 has updated the ship design to account for the increased weight.

The JPALS acquisition strategy separates the program into seven increments. Increment 1 is separated into two phases, A and B. Increment 1B—aircraft integration—will begin development in 2012 and integrate the system with the avionics of the F/A-18E/F, EA-18G, and MH-60R/S. Increment 2—land-based—will be led and funded by the Air Force and was expected to begin development during 2011.

### Program Office Comments

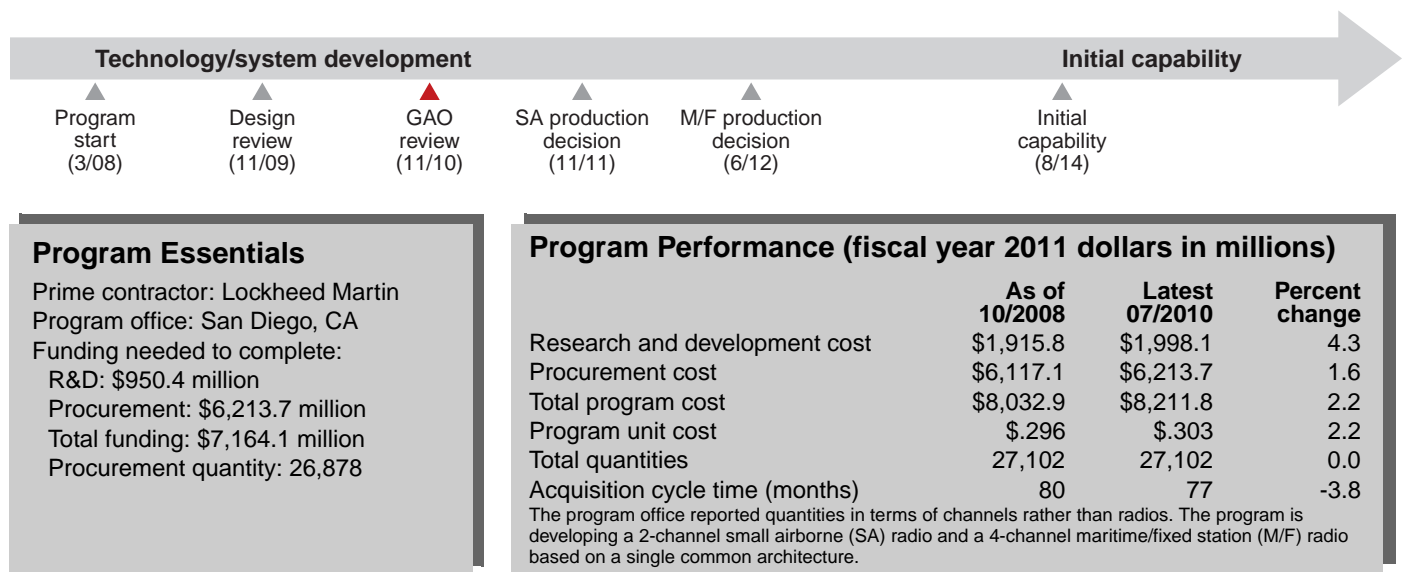
In commenting on a draft of this assessment, the Navy generally concurred with this assessment. Officials stated that the JPALS increment 1A program is on track for system integration with acceptable risk, that cost and schedule performance are within the baseline plan, and that the system requirements and acquisition strategy continue to be accurate, supportable, and executable. The Navy also provided technical comments, which were incorporated as appropriate.

## Airborne and Maritime/Fixed Station Joint Tactical Radio System (AMF JTRS)

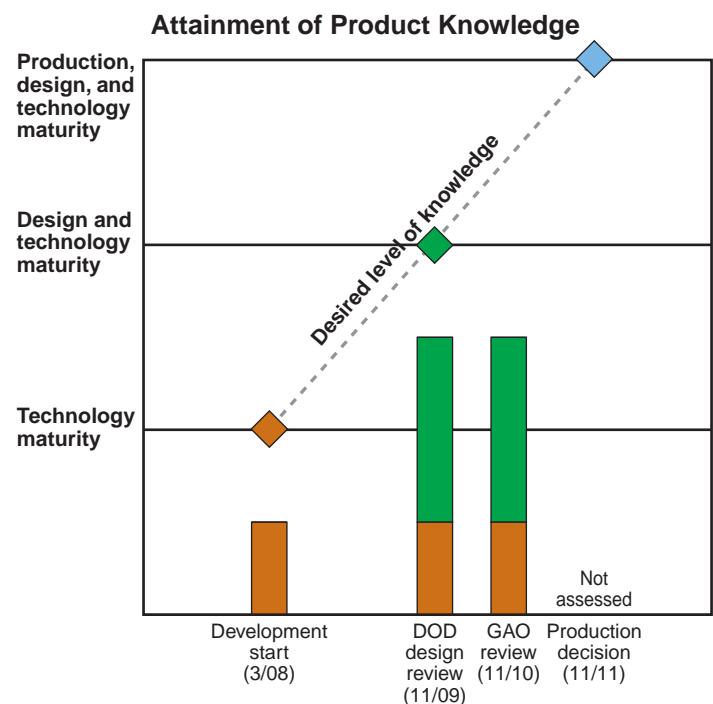
DOD's JTRS program is developing software-defined radios that will interoperate with existing radios and increase communications and networking capabilities. A joint program executive office provides a central acquisition authority that cuts across the military services. Program and product offices develop hardware and software for users with similar requirements. The AMF program will develop radios and associated equipment for integration into nearly 160 different types of aircraft, ships, and fixed stations.



Source: Department of Defense.



The AMF JTRS program completed its design review in November 2009 with its five critical technologies nearing maturity and its design stable. There will be an independent technology readiness assessment before the small airborne variant production decision, currently planned for November 2011. AMF JTRS production processes are also approaching maturity with manufacturing sites having demonstrated a capability to produce components or subsystems in a production-relevant environment. Each of the AMF variants will undergo initial operational test and evaluation after the program's initial production decision. AMF JTRS quantities could increase depending on whether the Navy and Marine Corps decide to acquire AMF JTRS small airborne radios for their networking capabilities.



## AMF JTRS Program

### Technology Maturity

DOD certified the AMF JTRS program for entry into system development in March 2008 with all five of its critical technologies nearing maturity and demonstrated in a relevant environment. Prior to the start of system development, the AMF JTRS program took steps to develop key product knowledge. In 2004, the program awarded competitive system design contracts to two industry teams led by Boeing and Lockheed Martin to help mitigate technical risks and address key integration challenges. According to program officials, an independent technology readiness assessment will be performed in preparation for the small airborne variant production decision, which is scheduled for November 2011.

### Design Maturity

The AMF JTRS design appears stable. The program reported that all of its expected design drawings were releasable when it completed its design review in November 2009. AMF JTRS' ability to demonstrate that the system meets its performance requirements is dependent on waveforms and network management services from the JTRS Network Enterprise Domain program. Of the two open items remaining from the design review, program officials consider the ability to route and retransmit between radio channels to be high risk. More specifically, the program is concerned that a needed waveform may not be available in time to allow operational testers to complete testing before the program's small airborne variant production decision in November 2011. Program officials assessed the other open item—security certification from the National Security Agency—as a medium risk. Both the program office and National Security Agency agree that there are currently no certification issues with the design. Once the National Security Agency certifies AMF JTRS, any changes will require an additional certification. Certification requirements may impact the system verification testing schedule.

### Production Maturity

The AMF JTRS program expects to have mature production processes before beginning production. A joint government-contractor assessment team has conducted manufacturing readiness level assessments—which include assessing statistical

process controls—at each manufacturing site. Consistent with best practices, the sites are expected to demonstrate the ability to produce production-representative units on pilot lines before beginning low-rate production. Several manufacturing sites have already demonstrated a capability to produce prototype components or subsystems in a production-relevant environment.

### Other Program Issues

AMF JTRS quantities could change depending on the Navy and Marine Corps' strategy for acquiring networking capabilities. While all of the services are planning to buy maritime/fixed station radios, the Army and Air Force are currently the only services planning to purchase the small airborne AMF JTRS radios. A March 2008 acquisition decision memorandum removed this requirement for the Navy and the Marine Corps and indicated that they plan to rely on the less capable ARC-210 radios for their airborne communications needs. While the ARC-210 radio is being upgraded, it will not have the waveforms for air-to-air and air-to-ground data networking. In August 2008, the Under Secretary of Defense for Acquisition, Technology and Logistics directed the JTRS joint program executive office, the Office of the Assistant Secretary of Defense for Networks and Information Integration (NII), along with the Joint Staff and military services, to assess issues and options related to replacing currently fielded ARC-210 radios with AMF JTRS capabilities. According to an NII official, this assessment has still not been initiated.

### Program Office Comments

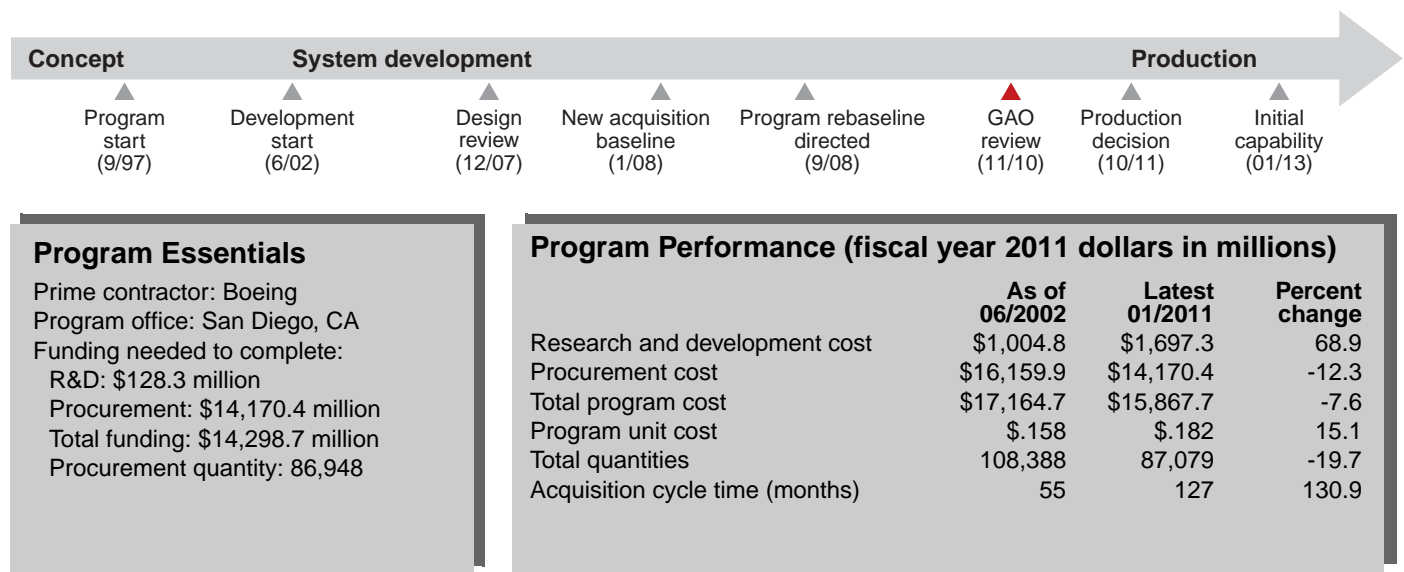
In commenting on a draft of this assessment, the Joint Program Executive Office JTRS provided technical comments, which were incorporated as appropriate.

## Joint Tactical Radio System (JTRS) Ground Mobile Radios (GMR)

DOD's JTRS program is developing software-defined radios that will interoperate with selected radios and increase communications and networking capabilities. The JTRS GMR program is developing radios for ground vehicles. JTRS GMR depends on waveforms being developed by the JTRS Network Enterprise Domain program, and shares interdependencies with the JTRS Handheld, Manpack, Small Form Fit program as well as the JTRS Airborne and Maritime/Fixed Station program.



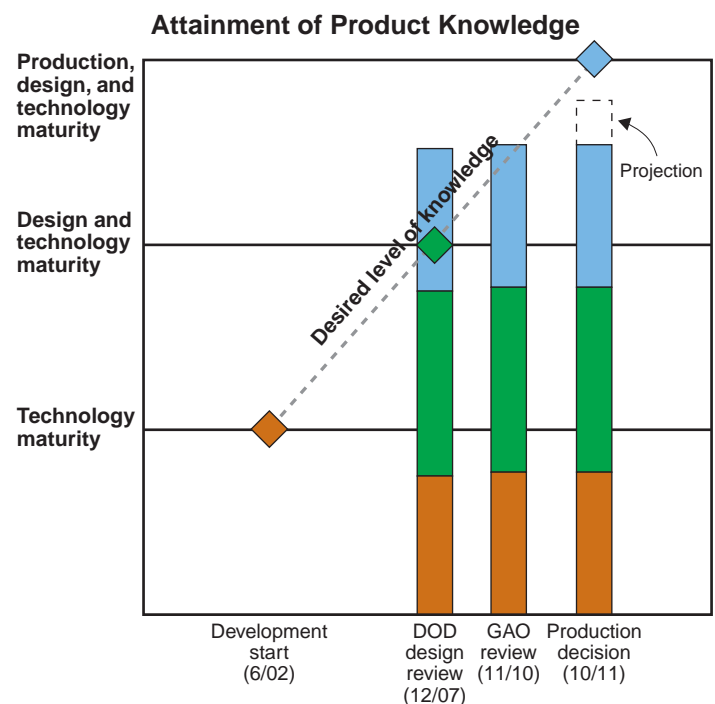
Source: Department of Defense.



### Program Essentials

Prime contractor: Boeing  
 Program office: San Diego, CA  
 Funding needed to complete:  
 R&D: \$128.3 million  
 Procurement: \$14,170.4 million  
 Total funding: \$14,298.7 million  
 Procurement quantity: 86,948

The JTRS GMR program expects to have its critical technologies mature, design stable, and most of its production processes in control by its planned October 2011 production decision. However, the JTRS GMR limited user test and production decision may be delayed to allow the program to test the GMR radio with its final software build and better assess the maturity of the wideband networking waveform. Even if the JTRS GMR limited user test and production decision are delayed, the Army's Early Infantry Brigade Combat Team program still plans to request approval to procure the radios for its next two brigades. The JTRS GMR program has yet to fully test key networking capabilities and receive its final National Security Agency certification. The program expects the Office of the Director, Cost Analysis and Program Evaluation, to complete a new independent cost estimate in January 2011.





## **JTRS GMR Program**

### **Technology Maturity**

The JTRS GMR program started system development in 2002 with none of its 20 critical technologies mature and demonstrated in a realistic environment. The JTRS GMR program expects to have its critical technologies mature by its planned October 2011 production decision. According to the program office, 11 of the 19 current critical technologies are now mature, 7 are nearing maturity, and 1 is still immature. The immature critical technology—bridging/retransmission software—is to be tested as part of GMR's multiservice operational test and evaluation, which is scheduled to begin in the fourth quarter of fiscal year 2012.

JTRS GMR relies on the wideband networking waveform—among other waveforms—to meet the requirements of key users, most notably the Early Infantry Brigade Combat Team (E-IBCT) program. While program officials reported the wideband networking waveform to be approaching maturity, the Office of the Director, Defense Research and Engineering (DDR&E), assessed the waveform's maturity to be substantially lower in a March 2010 technology readiness assessment for the E-IBCT program. According to the program office, there have been discussions between the JTRS program executive office and the Army about delaying GMR's limited user test—which was scheduled for completion in December 2010—until later in fiscal year 2011. The delay would allow the program to test the GMR radio with its final software build and collect more data for DDR&E to better assess the maturity of the wideband networking waveform. Testing the radio with its final software build could reduce the risk of late, costly design changes in production.

According to program officials, the most significant technical challenge remaining for GMR is meeting security requirements. The program's security verification test was scheduled for the fourth quarter of fiscal year 2010. The program expects to receive its final security certification from the National Security Agency in the third quarter of fiscal year 2011.

### **Design Maturity**

The design of the JTRS GMR appears stable with over 90 percent of the total expected design releasable to manufacturing. However, until all its technologies are mature, key waveforms have been fully integrated and tested, and the program's final security certification is received, the potential for design changes remains.

### **Production Maturity**

The JTRS GMR program has reported that 27 of its 35 critical manufacturing processes will be in statistical control by the program's planned October 2011 production decision. By not having all these processes in statistical control at production start, there is a greater risk that the radio will not be produced within cost, schedule, and quality targets. However, prior to its production decision, the program will demonstrate its critical manufacturing processes on a pilot production line. In addition, the program has delivered 91 engineering development model sets for use in developmental and operational testing.

### **Other Program Issues**

Until a complete and comprehensive cost estimate is developed, JTRS GMR program costs will remain uncertain. In August 2008, the Under Secretary of Defense for Acquisition, Technology and Logistics directed the JTRS GMR program to update its cost estimate and revise its acquisition program baseline. Program officials expect the Office of the Director, Cost Analysis and Program Evaluation, to complete an independent cost estimate by August 2011.

### **Program Office Comments**

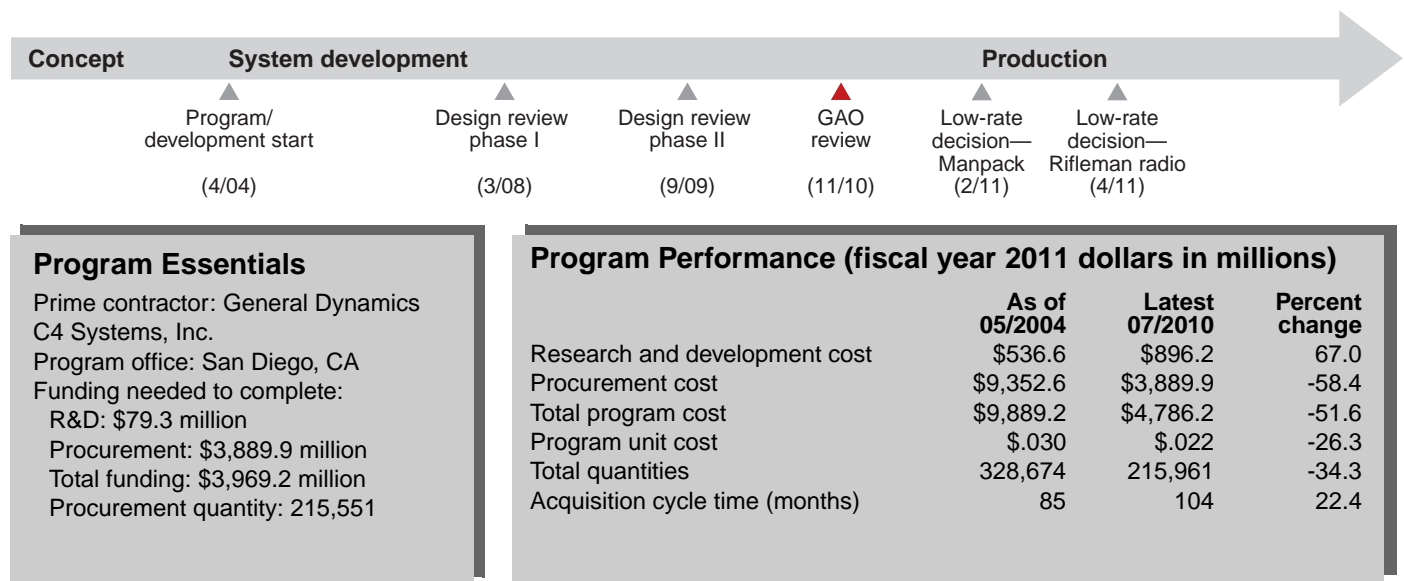
In commenting on a draft of this assessment, the JTRS Joint Program Executive Office provided technical comments, which were incorporated as appropriate.

## Joint Tactical Radio System (JTRS) Handheld, Manpack, and Small Form Fit (HMS)

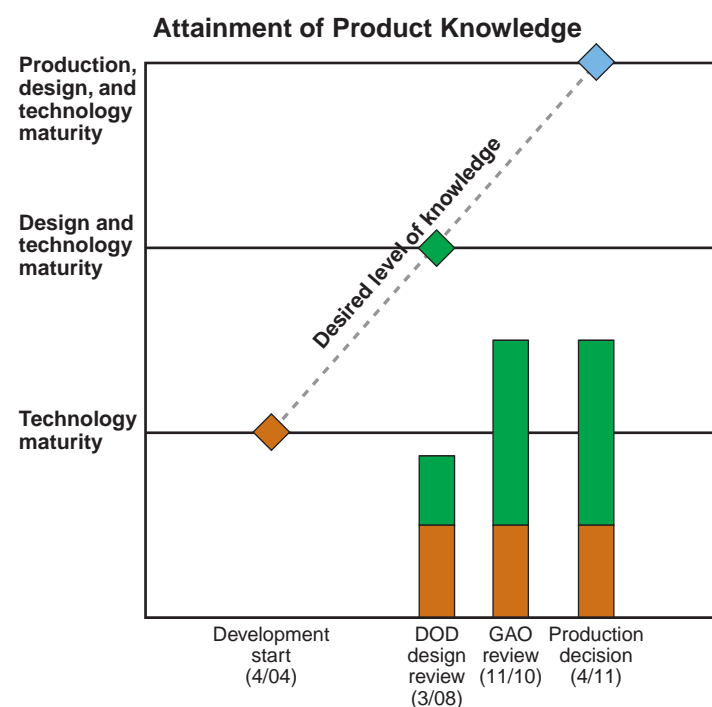
DOD's JTRS program is developing software-defined radios that will interoperate with existing radios and increase communications and networking capabilities. The JTRS HMS program has two concurrent phases of development. Phase 1 includes the Rifleman radio and two small form fit radios. Phase 2 consists of the manpack radio and two additional small form fit radios, all of which are for use in a classified security domain. We assessed phase 1 and made observations on phase 2.



Source: © 2009-2010 General Dynamics.



The Rifleman radio's production decision has been delayed from August 2010 to approximately April 2011, and the manpack radio's production decision is also at risk. In addition, since August 2009, the program's estimated procurement cost increased from \$2.5 billion to \$3.9 billion, as engineering design models were produced and the program learned more about actual costs. While this amount is less than half the program's original estimate, it is planning to buy far fewer radios—in particular the more expensive handheld and manpack radios—than initially planned.





## **JTRS HMS Program**

### **Technology Maturity**

According to the JTRS HMS program, its phase 1 critical technologies—logical partitioning and software power management—are nearing maturity. In October 2010, the Army assessed the Early Infantry Brigade Combat Team and concluded that one of the JTRS HMS small form fit radios was mature, and in January 2011, the Director, Defense Research and Engineering, concurred with this assessment. Additionally, the program office reported that it will demonstrate the Rifleman radio is fully mature during operational testing in January 2011.

The Army has not assessed the maturity of any of the program's four phase 2 technologies, but the program office reported that it will demonstrate that the manpack radio is fully mature during operational testing in February 2011. The program office has also reported that the manpack radio is currently meeting its size, weight, and power requirements.

### **Design Maturity**

According to the JTRS HMS program office, the phase 1 design is now stable. The phase 1 Rifleman radio has been reconfigured to address issues identified in its 2009 limited user test. The program office reported that the radio now has fewer parts; meets size, weight, and battery requirements; and provides increased reliability and range. The phase 2 design continues to change. JTRS HMS and the Nett Warrior program, which will use the phase 2 small form fit B radio, are investigating alternatives to better accommodate Nett Warrior's updated requirements, but the program office does not expect this redesign to be a challenge because it will not involve new technology.

### **Production Maturity**

According to the JTRS HMS program, its production processes are mature. In 2010, the program identified one critical manufacturing process and reported it was in control. In 2009, the program identified 24 critical manufacturing processes, but it no longer considers any of these processes critical because their maturity has increased.

### **Other Program Issues**

The production decision for the Rifleman radio has been further delayed from August 2010 to approximately April 2011, and the manpack radio's planned February 2011 production decision is also at risk. The waveforms targeted for the radio's limited user test are being operationally tested in February 2011; the National Security Agency is not scheduled to complete certification of the manpack radio until after successful verification testing in May 2011; and the MUOS waveform that the manpack radio is required to use is not scheduled to be operationally tested until 2012.

Since August 2009, the program's estimated procurement cost has increased from \$2.5 billion to \$3.9 billion, as engineering design models were produced and the program learned more about actual costs. While this amount is less than half the program's original estimate, it is planning to buy far fewer radios—in particular the more expensive handheld and manpack radios—than initially planned.

### **Program Office Comments**

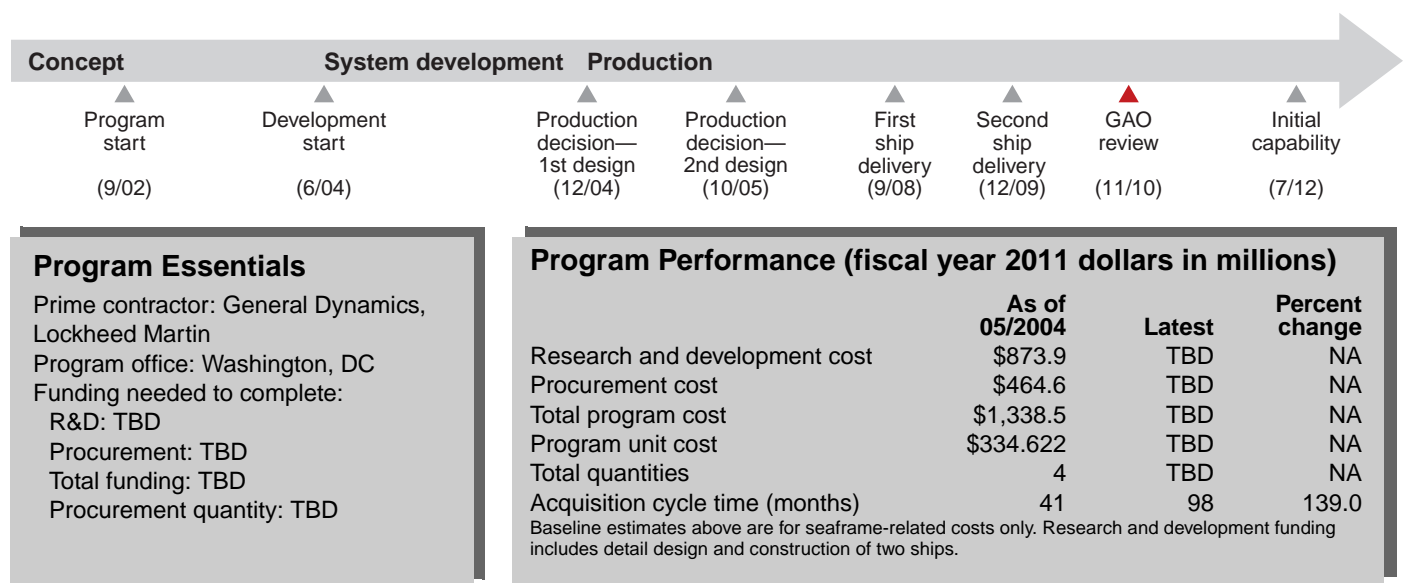
In commenting on a draft of this assessment, the JTRS Joint Program Executive Office provided technical comments, which were incorporated as appropriate.

## Littoral Combat Ship (LCS)

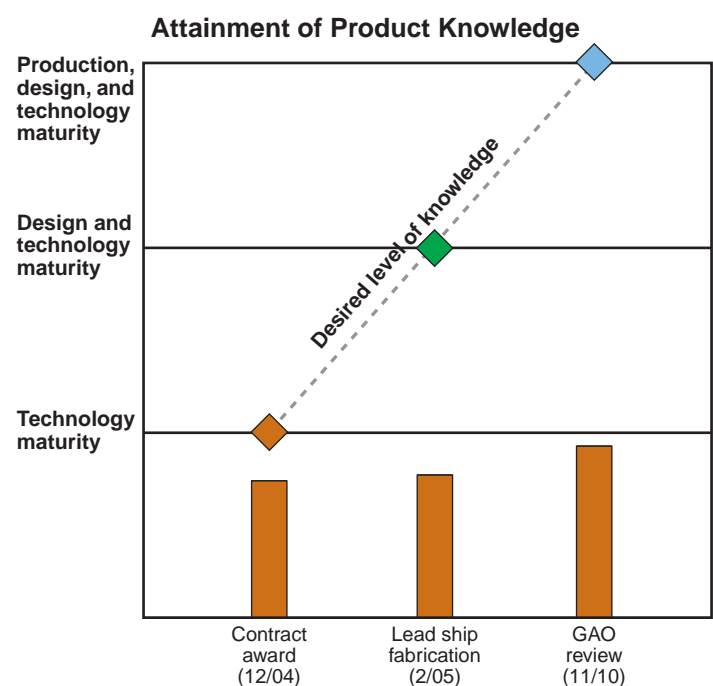
The Navy's LCS is designed to perform mine countermeasures, antisubmarine warfare, and surface warfare missions. It consists of the ship itself, or seaframe, and the mission package it deploys. The Navy is procuring the first four seaframes in two unique designs. The first seaframe (LCS 1) was delivered in September 2008. The second seaframe (LCS 2) followed in December 2009. We assessed both seaframes. See pages 99-100 for an assessment of LCS mission packages.



Sources: Lockheed Martin (left); General Dynamics (right).



The Navy is building the third and fourth LCS seaframes without having matured all the critical technologies or having achieved a stable design. Three of 19 seaframe critical technologies are still only nearing maturity and the Navy reported last year that LCS 3 and LCS 4 began fabrication with only 69 percent and 57 percent of basic and functional drawings complete, respectively. In addition, the Navy's efforts to resolve technical issues affecting the lead ships have led to design changes to LCS 3 and LCS 4 during construction, several of which remain in progress. Following failed contract negotiations in 2009 for fiscal year 2010-funded ships, the Navy twice restructured the program's acquisition strategy. This process culminated in December 2010 when the Navy awarded contracts for 10 ships of each design between fiscal years 2010 and 2015.



## LCS Program

### Technology Maturity

Sixteen of 19 critical technologies for both LCS designs are mature. Three technologies—LCS 1's overhead launch and retrieval system and LCS 2's trimaran hull and aluminum structure—are nearing maturity. Further, launch, handling, and recovery systems, which are essential to the LCS antisubmarine warfare and mine countermeasures missions, are still being refined for both designs. For LCS 1, Navy simulations have identified risks in safely launching and recovering mission systems that experience pendulous motion during handling—such as the remote multimission vehicle and unmanned surface vehicle systems. These operations may be complicated by unacceptably high water levels intruding into the ship's launch bay during high sea states. On LCS 2, the twin boom extensible crane system—designed to launch, handle, and recover watercraft—contains unproven elements. The Navy reports recent progress on these systems including (1) successful operation and movement of an embarked 11-meter rigid-hull inflatable boat onboard LCS 1 in March 2010, (2) synthetic lift lines on LCS 2 successfully completing a 200 percent lift test, and (3) routine usage of a straddle carrier to move an 11-meter rigid-hull inflatable boat (with stowage cradle) and berthing modules around the LCS 2 mission bay. Navy officials also report that testing of LCS 2's twin-boom extensible crane is progressing.

### Design and Production Maturity

The Navy provided historical data on design completeness that was inconsistent with data it provided to GAO last year, but officials did not respond to requests for clarification. The data provided by the Navy last year indicated that the LCS 3 and LCS 4 began fabrication with only 69 percent and 57 percent of basic and functional drawings complete, respectively. The Navy also could not provide this data for the LCS 1 and LCS 2. GAO's work on shipbuilding best practices has found that leading commercial firms assess a ship design as stable when 100 percent of these drawings are complete. By delaying construction start until basic and functional design is completed and a stable design is achieved, shipbuilders minimize the risk of design changes and the subsequent costly rework and out-of-sequence work these changes can drive.

The Navy used a concurrent design-build strategy for LCS 1 and LCS 2 seaframes, which proved unsuccessful. Implementation of new design guidelines, delays in major equipment deliveries, and strong focus on achieving schedule and performance goals resulted in increased construction costs. The Navy's ongoing efforts to resolve technical issues affecting LCS 1 and LCS 2, implement cost reduction measures, and increase mission capability have led to design changes for LCS 3 and LCS 4. These changes are significant and have affected the configuration of several major ship systems including propulsion, communications, electrical, and navigation.

### Other Program Issues

After unsuccessful contract negotiations for fiscal year 2010–funded seaframes, the Navy outlined a new acquisition strategy for the LCS program in September 2009 aimed at improving affordability by selecting one seaframe design for the fiscal year 2010 ships and beyond. In November 2010, the Navy amended this strategy and proposed contracting for 10 ships of each seaframe design through fiscal year 2015. In December 2010, Congress approved this revised strategy, and the Navy subsequently awarded fixed-price incentive contracts for up to 10 ships each to Lockheed Martin and Austal USA.

### Program Office Comments

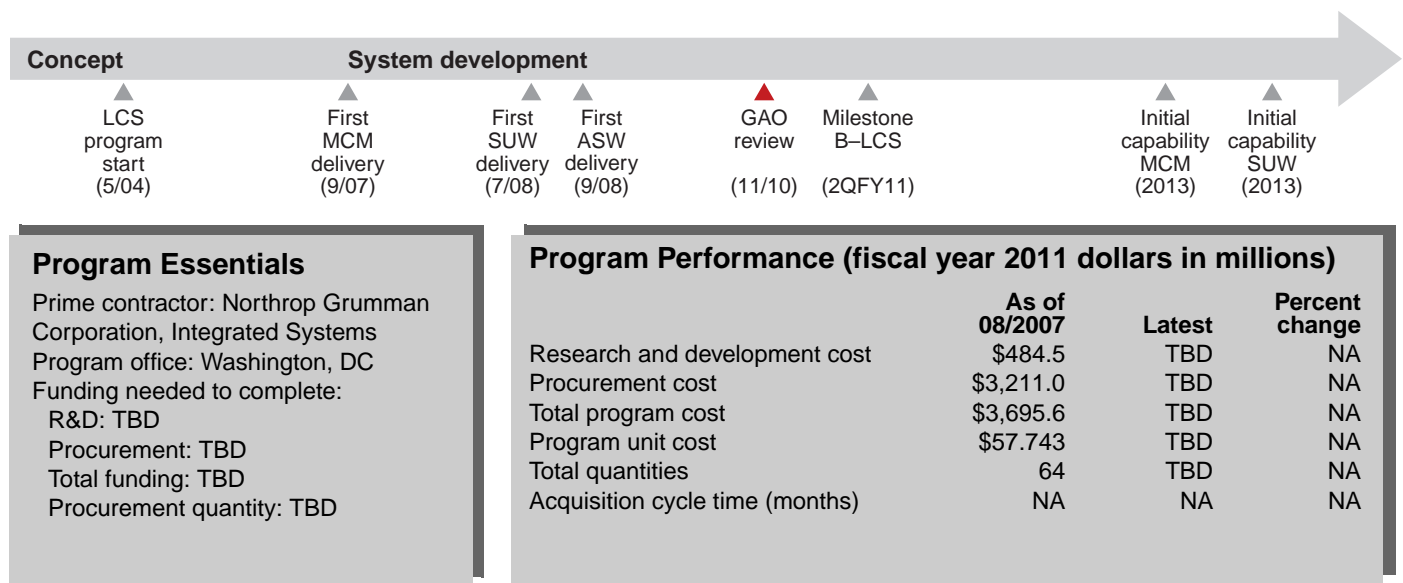
According to the Navy, two industry teams (1) have each designed, built, and delivered to the Navy a lead ship meeting the LCS performance requirements and (2) are currently building their second ships, with lessons learned from the lead ships incorporated into the designs. The Navy states that both designs are stable, with LCS 3 and LCS 4 having experienced minimal design changes to-date, and cites impressive learning and investment by both shipbuilders as well as significant improvement in cost and schedule performance. According to the Navy, LCS 3 launched on December 4, 2010, at over 80 percent complete. This level of completeness at launch, and the improvement in cost and schedule performance by both shipbuilders, provides the Navy confidence that risk of design change and out-of-sequence work is minimal. The Navy also provided technical comments, which were incorporated as appropriate.

## Littoral Combat Ship-Mission Modules

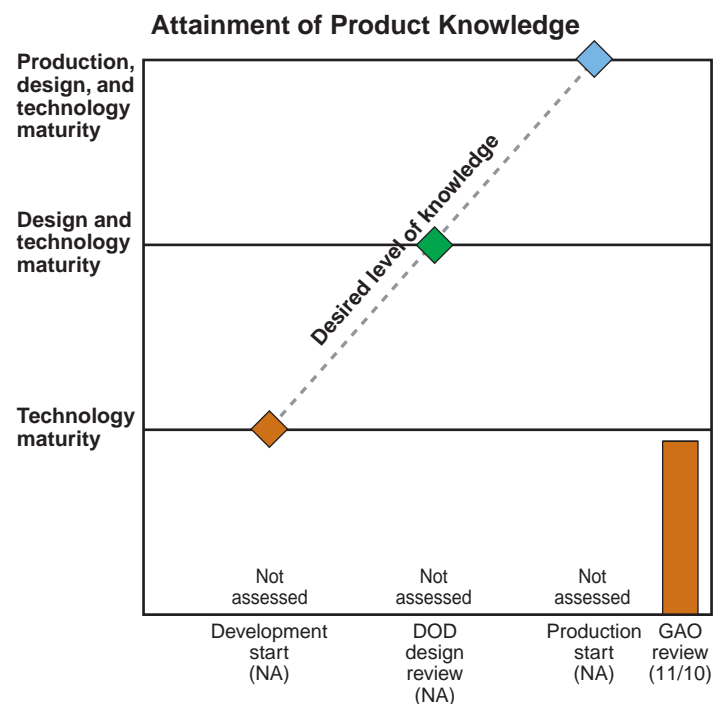
The Navy's Littoral Combat Ship (LCS) will perform mine countermeasures (MCM), surface warfare (SUW), and antisubmarine warfare (ASW) missions using modular mission packages. Packages include weapons and sensors that operate from MH-60 helicopters or unmanned underwater, aerial, or surface vehicles. Initial packages include engineering development models and production-representative systems of some, but not all, systems planned. Mission capability improves with each package delivered until it reaches a baseline capability.



Source: © Northrop Grumman Corporation.



The Navy has accepted delivery of five partially capable mission packages. At full baseline capability, packages require a total of 21 critical technologies, including 11 sensors, 6 vehicles, and 4 weapons for their operation. Most of these technologies are mature; however, some mission systems have experienced test failures and have not demonstrated the promised capability. Individual systems in the mine countermeasures packages do not meet reliability requirements, and the Navy is currently evaluating alternatives to replace the cancelled Non-Line-of-Sight Launch System (NLOS-LS) and missiles. The Navy is also reexamining the content of the ASW package. Due to developmental delays with key mission systems, the Navy risks acquiring significant numbers of seaframes and mission packages before the mission packages are proven.



## LCS Modules Program

### Technology Maturity

At its full baseline capability, operation of the MCM, SUW, and ASW packages on LCS requires a total of 21 critical technologies, including 11 sensors, 6 vehicles, and 4 weapons. Of these technologies, 18 are mature and have been demonstrated in a realistic environment.

The Navy has accepted delivery of two partially capable MCM mission packages. According to program officials, in 2010 the MCM mission package completed end-to-end testing, and two MCM systems—the AN/AQS-20A sonar and Airborne Laser Mine Detection System—have completed developmental testing in separate test events. Two other systems—the Unmanned Surface Vehicle (USV) and Unmanned Surface Sweep System—have not yet been demonstrated in a realistic environment, and a third—the Remote Minehunting System (RMS)—has been delayed because of poor reliability. Program officials report that the Navy is assessing alternative USV designs because the current system does not meet power output requirements necessary to support the towed surface sweep system. The RMS, which is its own major defense acquisition program, experienced a Nunn-McCurdy unit cost breach of the critical threshold in December 2009, due to cost increases resulting from a 51 percent reduction in quantity and efforts to improve reliability. In June 2010, the Office of the Secretary of Defense completed its review and certified RMS for continuation. According to Director, Operational Test and Evaluation, officials, RMS reliability has improved from 7.9 hours to nearly 45 hours between failures. According to program officials, the Navy plans to recommence RMS production in fiscal year 2015. Further, program officials report that the Rapid Airborne Mine Clearance System has been removed from the package while the Navy evaluates more cost-effective alternatives for meeting desired capability delivery time frames.

The Navy has accepted delivery of two partially capable SUW mission packages and expects to accept delivery of a third mission package in fiscal year 2011. The Navy will resume procuring SUW packages in fiscal year 2012. The 30 millimeter gun was test-fired from LCS 1 in September 2009 and according to program officials, integrated with the

LCS 1 combat system and demonstrated at sea in April 2010. In May 2010, DOD cancelled the Non-Line-of-Sight Launch System due to cost and technical challenges. Officials note the Navy is evaluating other alternatives and expects to complete evaluation by the second quarter of fiscal year 2011.

The Navy accepted delivery of one partially capable ASW mission package in September 2008. However, program officials stated that the Navy plans to introduce new mission systems and classified capabilities before procuring additional ASW packages. Program officials report that the Navy has completed development and testing of the first ASW mission package to evaluate operational concepts and refine requirements.

### Other Program Issues

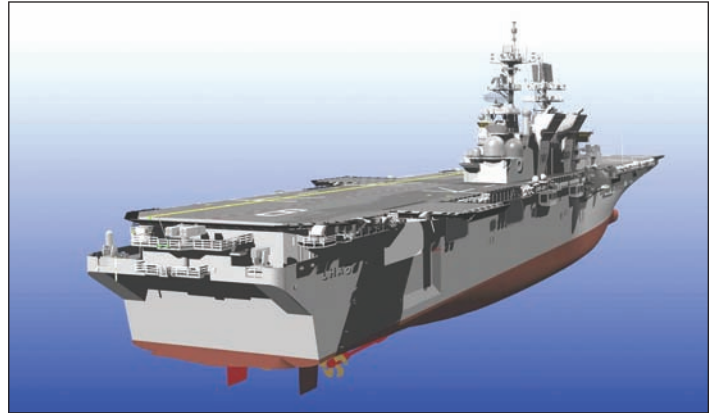
The Navy plans to purchase 18 ships and 13 mission packages between fiscal years 2011 and 2015, but developmental delays in key mission package systems mean the Navy will acquire significant numbers of seaframes before mission packages are proven. GAO has reported since 2007 on challenges developing systems constituting LCS mission packages and integrating them with their host platforms. These challenges have delayed the planned delivery of baseline capability by several years. Until mission package performance is proven, the Navy risks investing in a fleet of ships that does not deliver its promised capability and is largely constrained to self-defense as opposed to mission-related tasks.

### Program Office Comments

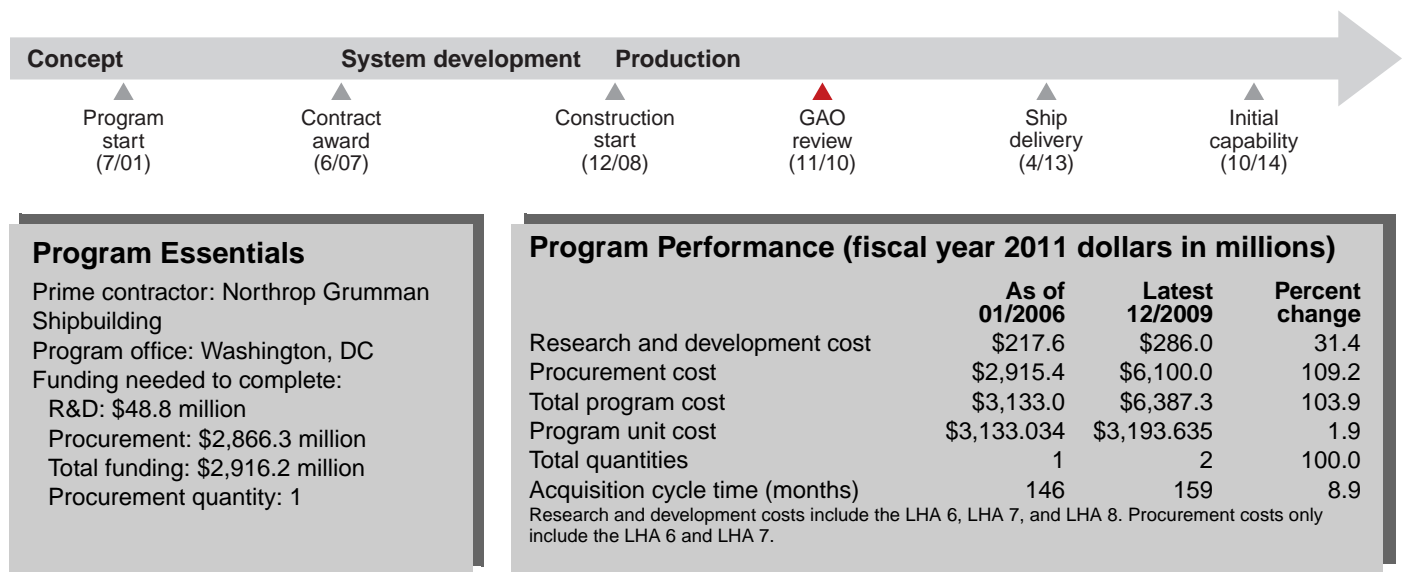
The Navy stated that recent testing has been comprehensive, operationally relevant, and successful. According to the Navy, the SUW mission package supported early deployment of LCS 1, providing a counter-illicit trafficking capability. Further, the Navy stated that from program inception, the acquisition strategy for mission package has employed an incremental approach and remained stable, fielding systems as they achieve the required level of maturity. According to the Navy, those few systems experiencing issues (NLOS-LS and RMS) are either being replaced with alternative systems or are targets of increased focus and attention. According to the Navy, the results have been positive in all cases. In addition, the Navy provided technical comments, which were incorporated as appropriate.

## LHA Replacement Amphibious Assault Ship

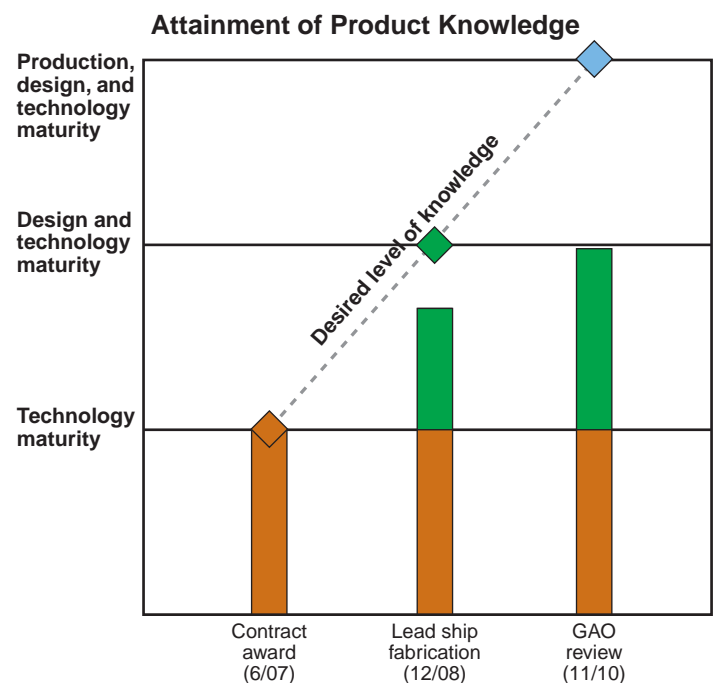
The Navy's LHA 6 will replace the LHA 1 Tarawa-class amphibious assault ships. The LHA 6 is a modified variant of the fielded LHD 8 amphibious assault ship and will feature enhanced aviation capabilities and is designed to support all Marine aviation assets in the Expeditionary Strike Group. LHA 6 construction began in December 2008. It is currently scheduled to be delivered in April 2013. The LHA 6 ship class includes three ships. We assessed LHA 6 and made observations on LHA 7 and LHA 8.



Source: U.S. Navy.



The LHA 6 began construction in December 2008 with mature technologies, but a design that was only 65 percent complete. Almost all detailed design drawings have now been released. In July 2009, the Secretary of the Navy certified that the LHA 6 program was ready to commence full shipbuilding construction activities. As of September 2010, the program office reported it had conducted unit readiness reviews for all of the ship's 216 assembly units, and the shipbuilder had started fabrication on 215 units. The LHA 6 program may incur cost growth due to the need for postdelivery rework of the ship's deck to cope with the intense, hot downwash from the Joint Strike Fighter.





## **LHA 6 Program**

### **Technology Maturity**

All LHA critical technologies were mature by the time the program awarded its construction contract in June 2007. DOD and the Navy concluded in 2005 that all LHA 6 components and technologies were fully mature and will have been installed on other ships prior to LHA 6 delivery. Although not considered critical technologies, the program has identified six key subsystems needed to achieve the LHA 6's full capabilities. Five of these are mature, installed on numerous Navy ships, and do not require modification for the LHA 6. The sixth, the Joint Precision Approach and Landing System, a Global Positioning System-based aircraft landing system, is still in development. While this system is necessary to realize the LHA 6's full capabilities, it is not required to meet its operational requirements. The program office has also previously identified the machinery control system as a potential risk. The shipbuilder expected to commence integrated testing of the machinery control system for LHA 6 in January 2011 in the land based test equipment.

### **Design Stability**

The LHA 6 began construction in December 2008 with only 65 percent of its design complete. Almost all detailed design drawings have now been released. The LHA 7 design will be very close to the LHA 6. Design changes will be limited. These changes include a new firefighting system and radar and command, control, communications, computers, and intelligence updates. Design changes may be more significant on the LHA 8 if the Navy includes a well deck on the ship. All LHA ships except LHA 6 and LHA 7 have a well deck. Officials report that reintroducing the well deck would affect aviation capabilities such as fuel storage space. The Navy will determine the final configuration, capabilities, and cost for the LHA 8 after trade studies are completed in fiscal year 2011. Program officials reported that decisions on the LHA 8 design and the potential increase in funding needed to execute them have not yet been determined.

### **Production Maturity**

In July 2009, the Secretary of the Navy certified that the LHA 6 program was ready to commence full shipbuilding construction activities. As of September 2010, the program office reported it had

conducted unit-level readiness reviews for all of the ship's 216 assembly units and the shipbuilder had started fabrication on 215 units.

### **Other Program Issues**

The LHA 6 is likely to experience further cost growth. Costly postdelivery rework of the ship's deck may be necessary to cope with the downwash from the Joint Strike Fighter. The heat from these aircraft could warp the LHA 6 deck or damage deck equipment. The Navy will conduct at-sea testing on USS WASP to determine if and how the LHA 6 and other Joint Strike Fighter-capable ships will need to modify their flight decks. The program office does not expect the Navy to finalize a solution to this issue prior to LHA 6 ship delivery.

### **Program Office Comments**

In commenting on a draft of this assessment, the Navy stated that the program manager is continually monitoring shipyard performance and is working closely with the shipbuilder to identify mitigation strategies. The Navy also provided technical comments, which were incorporated as appropriate.

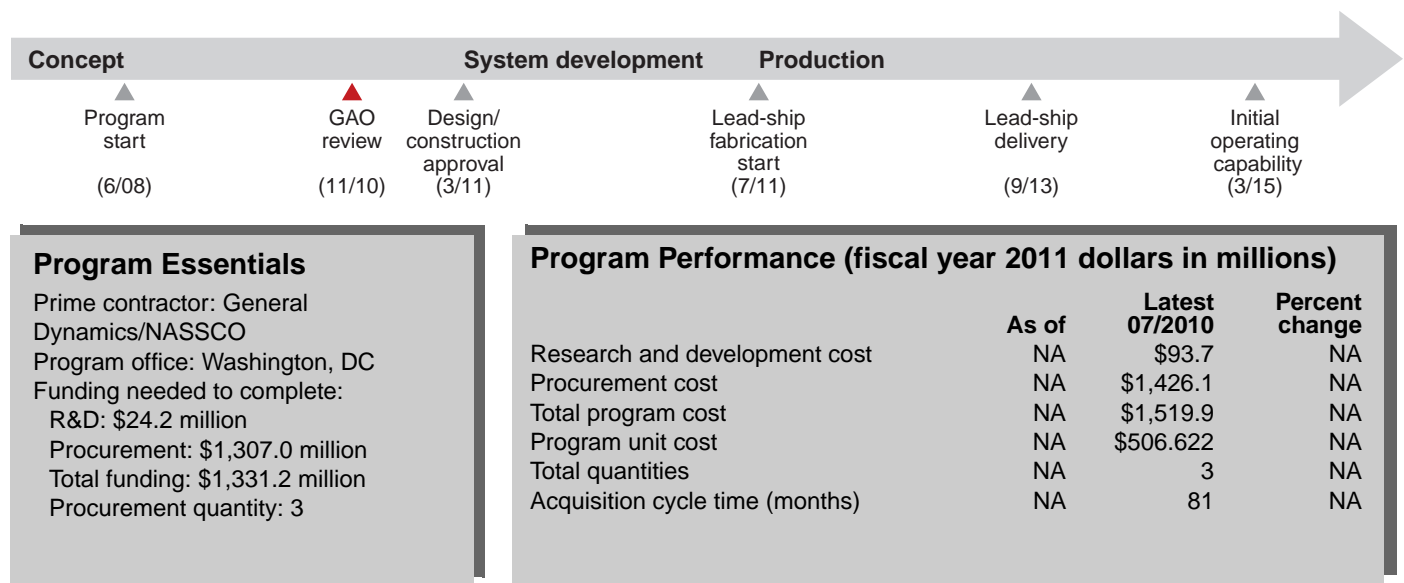


## Maritime Prepositioning Force (Future) / Mobile Landing Platform

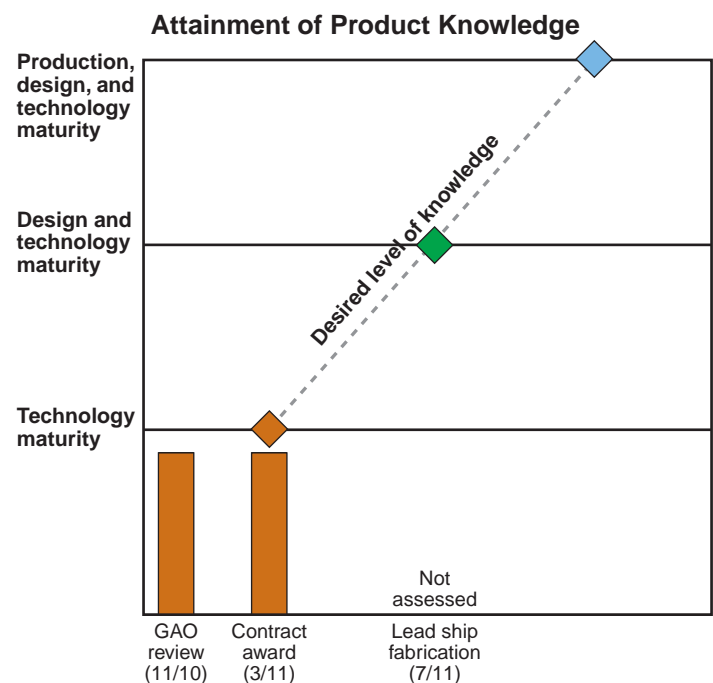
The Navy's Mobile Landing Platform (MLP) is one of four classes of ships in the Maritime Prepositioning Force (Future)—MPF(F)—squadron that supports seabasing. The MLP is designed to facilitate at-sea vehicle and cargo transfer in low-threat environments to support operations ashore. In 2010, the Navy restructured the MPF(F) program, which includes a lower-cost variant of the MLP based largely on a commercial oil tanker. The Navy plans to award the construction contract for the first of three MLP vessels in early 2011.



Source: Computer Sciences Corp.



The MLP program will award its detailed design and construction contract with three of its four current critical technologies mature. The remaining technology, operations with MLP and its supporting vessels, is nearing maturity. It is not expected to be mature before construction begins because it requires a complete or near complete MLP to be tested at-sea. The program is currently testing the technology using small-scale models. As part of the MPF(F) restructuring, the MLP program replaced most of its critical technologies. The redesigned MLP is largely based on a commercial oil tanker. The new design offers less capability, but reduces the program's cost and schedule. According to program officials, leveraging the design of a commercial oil tanker will allow them to have a higher level of design maturity and a lower level of technological risk prior to the start of construction.



## MPF(F)/MLP Program

### Technology Maturity

The MLP program will award its detailed design and construction contract with three of its current critical technologies mature and one nearing maturity. As a result of the MPF(F) restructure, the MLP adopted a new design and lowered the number of critical technologies from five to four, reducing MLP capabilities as well as costs. The technologies are designed to assist in the transfer of cargo between the MLP and other ships. The three technologies that have reached maturity—skin-to-skin vehicle transfer with the Large, Medium Speed Roll-on/Roll-off vessel, vehicle transfer with the Joint High Speed Vessel (JHSV), and the Landing Craft Air Cushion interface—were tested at-sea using surrogate platforms. Program officials reported that the vehicle transfer technologies—which use ramps to connect MLP to the large cargo vessel or the JHSV at-sea while in motion—were tested as recently as March 2010. Vehicle transfers with the JHSV are currently limited to operations in calm waters. The landing craft interface was tested at sea in March 2010 by loading landing craft at different speeds and approaches in varying sea states onto a surrogate MLP. While on the MLP, landing craft may receive cargo, undergo limited maintenance, and refuel. The last technology—landing craft operations with MLP and larger cargo vessel connected—requires the simultaneous interaction of two of the other technologies. Program officials do not expect this technology to reach maturity before construction as it requires a complete or near complete MLP for at-sea testing. Program officials said it is currently being tested using small scale models.

### Design Maturity

The MLP has undergone significant design changes due to the MPF(F) program restructure and budget reductions. The new MLP design will offer less cargo, personnel, and aviation capacity, but at a lower cost. The design is based on the Alaska-class crude oil carrier with modifications that allow the MLP to raise and lower itself into the water so that landing craft can float on and off. Program officials reported that the MLP will leverage approximately 60 percent of the commercial design. They also reported 81 percent of preliminary design drawings are complete and the three-dimensional design is underway. The largest changes will be to the central

portion of the ship, which will be modified to store supplies and vehicles, as well as the equipment needed for the landing craft interface. In the future, the MLP may be able to accommodate float-on modules to provide additional capabilities.

### Other Program Issues

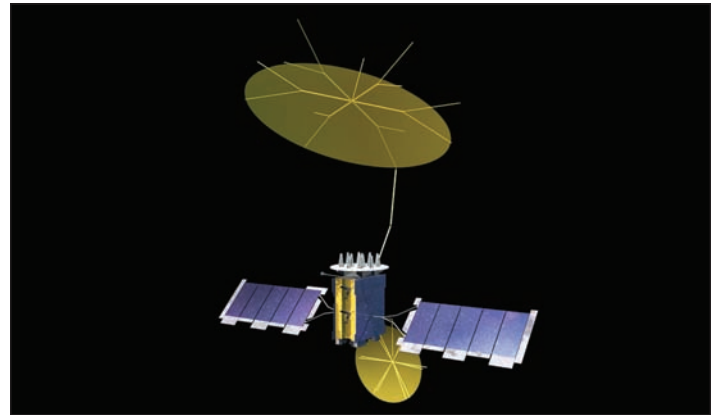
Due to resource constraints, the Navy has restructured MPF squadrons by deferring the construction of new Large, Medium Speed Roll-on/Roll-off vessels, redesignating two classes of ships out of the MPF(F), and reducing the capabilities and costs of the MLP. Additionally, the MPF(F) concept of operations has changed from assembling cargo on-board the MLP to assembling it onshore.

### Program Office Comments

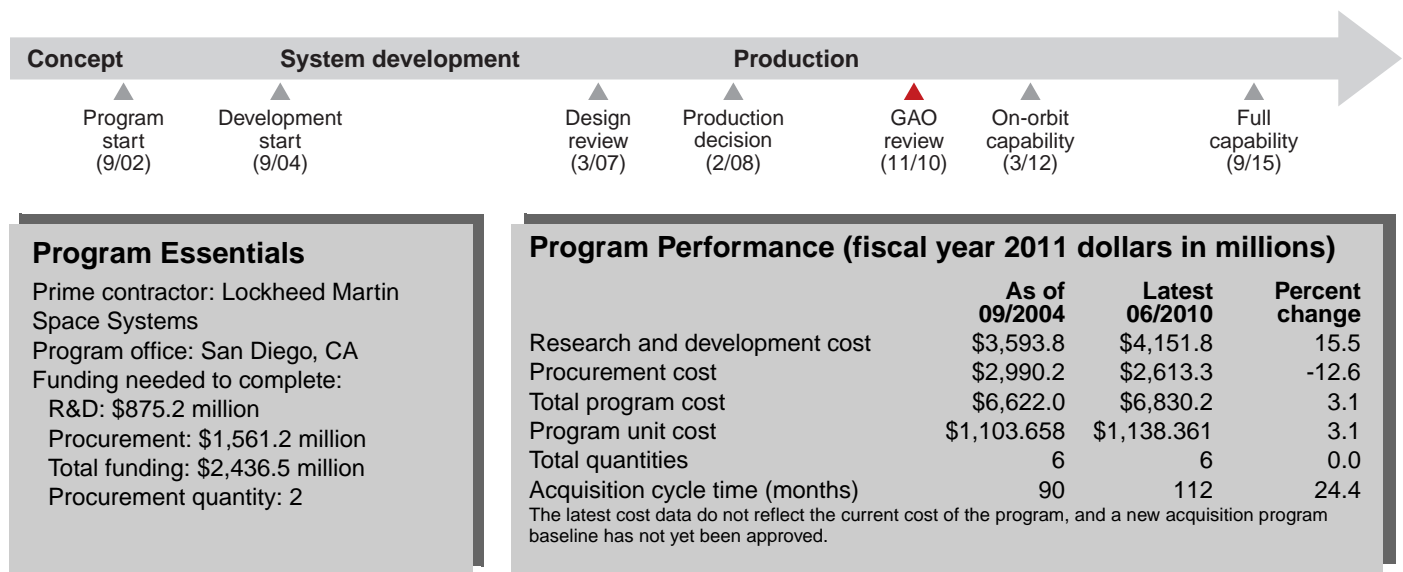
According to the MLP program, it is working with the Office of Naval Research and the Technology Readiness Assessment office to reassess MLP critical technologies. The program anticipates that this assessment will state that MLP has no critical technologies. The program has also identified a series of production-readiness criteria in the request for proposal for the construction contract, including having certain American Bureau of Shipbuilding drawings 100 percent complete, the three dimensional model by zone 90 percent complete, the model by block 65 percent complete, and work package kits 5 percent complete. According to the program, these criteria and the program's detailed plan for completing all design artifacts to support production will ensure the design is sufficiently mature for construction. The Joint Requirements Oversight Council has also validated all changes in MLP capabilities. The program office also provided technical comments, which were incorporated as appropriate.

## Mobile User Objective System (MUOS)

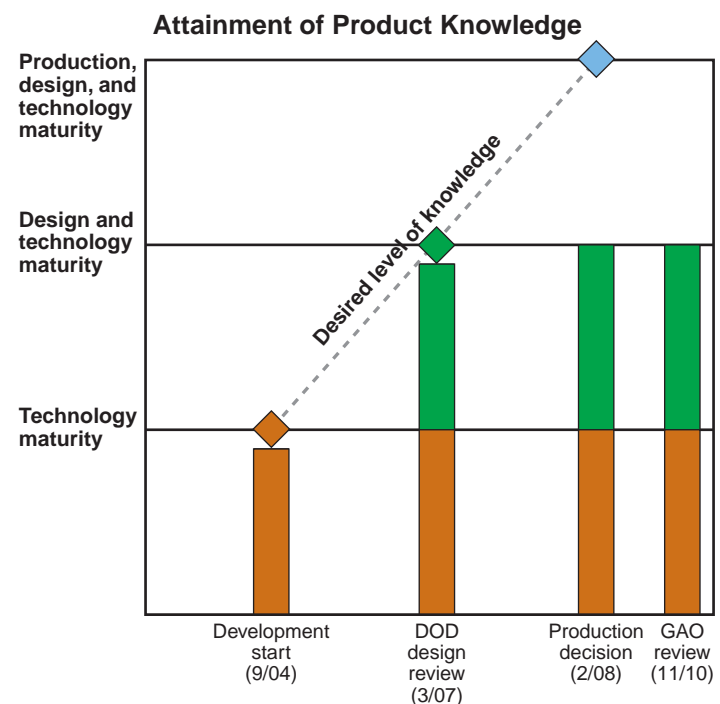
The Navy's MUOS, a satellite communication system, is expected to provide a worldwide, multiservice population of mobile and fixed-site terminal users with an increase in narrowband communications capacity and improved availability for small terminals. MUOS will replace the Ultra High Frequency (UHF) Follow-On (UFO) satellite system currently in operation and provide interoperability with legacy terminals. MUOS consists of a network of satellites and an integrated ground network. We assessed both the space and ground segments.



Source: © 2008 Lockheed Martin.



All MUOS critical technologies are mature and all design drawings have been released; however, design flaws discovered late in production continue to pose cost and schedule risks for the program. After a 2009 review of the program found that the MUOS schedule was optimistic and its budget was inadequate, the program developed more realistic cost and schedule baselines. The new cost baseline has not yet been approved. The current estimate for the first satellite to begin on-orbit operations is March 2012—24 months later than planned when the program began development. The delivery of MUOS capabilities is time-critical due to the operational failures of two UFO satellites. The MUOS program has taken several steps to address any potential capability gap that could occur prior to the first MUOS satellite beginning on-orbit operations.



## **MUOS Program**

### **Technology Maturity**

According to the program office, all eight MUOS critical technologies are mature and have been demonstrated in at least a realistic environment.

### **Design Maturity**

According to the program office, the MUOS design is stable and the design flaws discovered late in production have largely been resolved. However, design issues with UHF reflectors continue to pose cost and schedule risks for the program. Specifically, the UHF reflectors have been redesigned to mitigate signal interference and structural hardware bonding issues. According to the program, the late delivery of the UHF reflectors—which are on the program critical path for the first MUOS satellite launch—is the program's top challenge. The hinges that connect the solar panels and booms in the solar array wing assembly are also causing unwanted signal interference.

According to the program, it has mitigated the schedule effects of these design issues by proceeding in September 2010 with system-level vibration testing, which approximates the level of vibration experienced during launch, prior to incorporating all of the planned designed modifications for the reflectors and solar panels. According to DOD, system-level vibration testing has been completed and the risk associated with the nonflight components are being mitigated by conducting component-level vibration testing on these parts prior to their reinstallation on the spacecraft. According to the program, the reflectors and solar panels are going through rework and test in parallel with system-level thermal vacuum testing and are to be available for reinstallation on the spacecraft after system-level testing.

### **Production Maturity**

According to the program office, the production maturity of the first MUOS satellite is high. We could not assess production maturity because the program does not collect statistical process control data on its critical manufacturing processes. According to the program office, the space segment does collect, track, and analyze data on manufacturing process defects. While manufacturing defects have contributed to cost growth and schedule delays on

the program, the number of defects has decreased slightly over time as the maturity of the manufacturing process has increased.

### **Other Program Issues**

The importance of the first MUOS launch increased due to the unexpected failures of two UFO satellites. Based on the current health of on-orbit satellites, UHF communication capabilities are currently predicted to provide the required availability level until the first MUOS satellite begins on-orbit operations—currently planned for March 2012. However, the MUOS program is addressing the potential for a capability gap by activating dual digital receiver unit operations on a UFO satellite, examining the potential of purchasing or leasing UHF satellite communications services on a commercial satellite, and exploring the feasibility of expanded digital receiver unit operations on the legacy payloads of the MUOS satellites.

In 2009, a Navy-initiated review of the MUOS program found that while it was technically sound, its schedule was optimistic and its budget was inadequate. As a result, the program developed new cost and schedule baselines. The acquisition program baseline has been under revision since December 2009, but has not yet been approved. The prime contract cost baseline for the MUOS program was renegotiated in February 2010. According to the program, the prime contract cost baseline, which includes \$162 million in engineering change proposals, has increased about 61 percent since contract award in September 2004.

### **Program Office Comments**

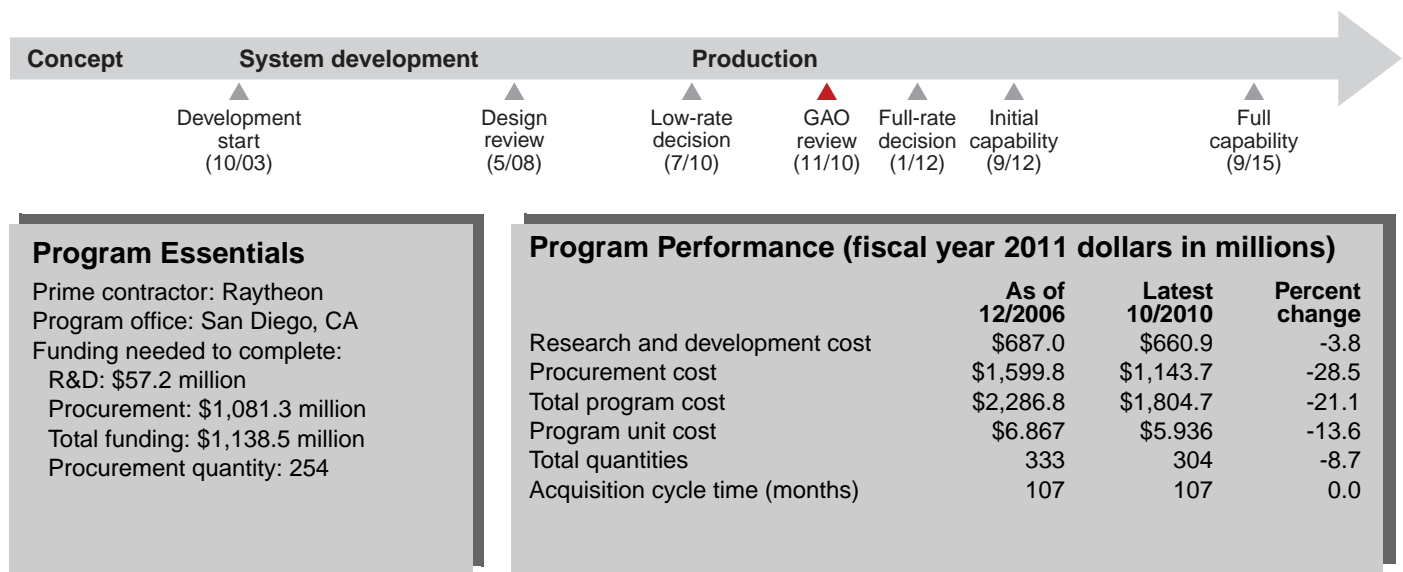
In commenting on a draft of this assessment, the Navy provided technical comments, which were incorporated as appropriate.

## Navy Multiband Terminal (NMT)

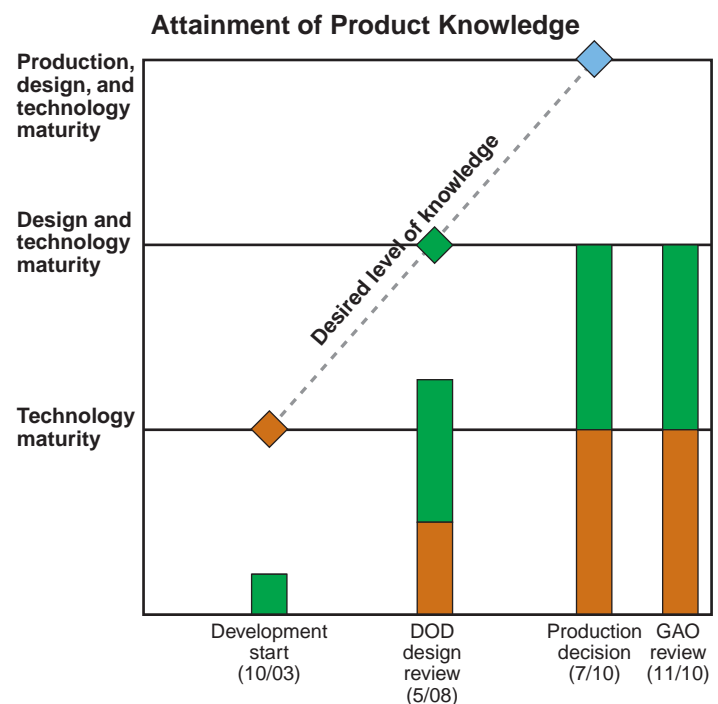
The Navy's NMT is the next-generation maritime military satellite communications terminal. It will be installed in existing ships, submarines, and shore sites. NMT is designed to work with the Air Force's Advanced Extremely High Frequency (AEHF) Satellite system to enhance protected and survivable satellite communications to naval forces. Its multiband capabilities will also enable communications over existing military satellite communication systems, such as Milstar, Wideband Global SATCOM, and the Defense Satellite Communications System.



Source: © 2008 Raytheon Company.



The NMT program entered production in July 2010 with mature critical technologies and a stable design, but without demonstrating its critical manufacturing processes are in statistical control—a key step for ensuring these processes are repeatable, sustainable, and capable of consistently producing quality parts. The NMT program began to produce production-representative engineering development models in May 2008. According to the NMT program, it used these models to mature and baseline its manufacturing processes. The program also plans to complete a manufacturing readiness assessment during fiscal year 2011 to support a full-rate production decision in fiscal year 2012. The NMT program is dependent on AEHF satellites to test its full range of capabilities. The first AEHF satellite was launched in August 2010, but a propulsion issue has delayed it from reaching its planned orbit.



## **NMT Program**

### **Technology Maturity**

The NMT program's two critical technologies—a multiband antenna feed and monolithic microwave integrated circuit power amplifiers for Q-band and Ka-band communication frequencies—are mature. Both of these technologies have been demonstrated in fully capable, production-representative engineering development models.

### **Design Maturity**

The NMT's design is stable. The program has released all of its expected design drawings and placed the design under configuration control. At its May 2008 design review, program officials reported that about 70 percent of the expected drawings were releasable to manufacturing.

### **Production Maturity**

The NMT program office entered production in July 2010 without demonstrating that its manufacturing processes were in statistical control—a key step for ensuring these processes are repeatable, sustainable, and capable of consistently producing high-quality parts. During a June 2008 technology readiness assessment, the program identified three critical manufacturing processes related to the Q-band and Ka-band monolithic microwave integrated circuits and the Q/Ka radome. The NMT program began to produce production-representative engineering development models in May 2008. According to the NMT program, it used its production run of 33 engineering development models to mature and baseline its manufacturing processes. This will allow the program to begin tracking statistical process control data. A manufacturing readiness level assessment is scheduled to occur during fiscal year 2011 to support a full-rate production decision review in fiscal year 2012.

### **Other Program Issues**

The NMT program is dependent on AEHF satellites to test its full range of capabilities. The first AEHF satellite was launched in August 2010; however, a faulty satellite propulsion system will delay the satellite from reaching its planned orbit by about 7 to 9 months. Delays with AEHF capability directly affect the ability of the NMT program to test the new higher data rate communications capability. However, NMT officials stated that the new higher

data rate can be tested with one AEHF satellite, should the Air Force configure it in that fashion. Additional AEHF satellites provide more coverage and program officials noted that initial operational capability can be achieved with two installed systems that have successfully completed system operational verification test. In addition, the NMT program can provide value to the fleet when it is fielded by accessing existing satellite communication systems such as the Defense Satellite Communications System, Milstar, Wideband Global SATCOM, Interim Polar, and UFO satellite constellations.

The NMT program's software lines of code have significantly increased since development start to accommodate software communications architecture requirements. Currently, software integration testing is over 80 percent complete with over 95 percent of the defects resolved. According to NMT program officials, the NMT program is containing most of the defects that it finds within phase, which is a good indicator because it is more efficient to correct problems within the phase in which they occur.

### **Program Office Comments**

In commenting on a draft of this assessment, the Navy stated that the NMT program has successfully entered the production phase and continues to successfully progress to provide deployed naval commanders with assured access to secure, protected, command and control and communication capabilities to support the exchange of warfighter-critical information. It will support the Navy's net-centric FORCEnet architecture and act as an enabler for transforming operational capability available to the warfighter. The Navy also provided technical comments, which we incorporated as appropriate.

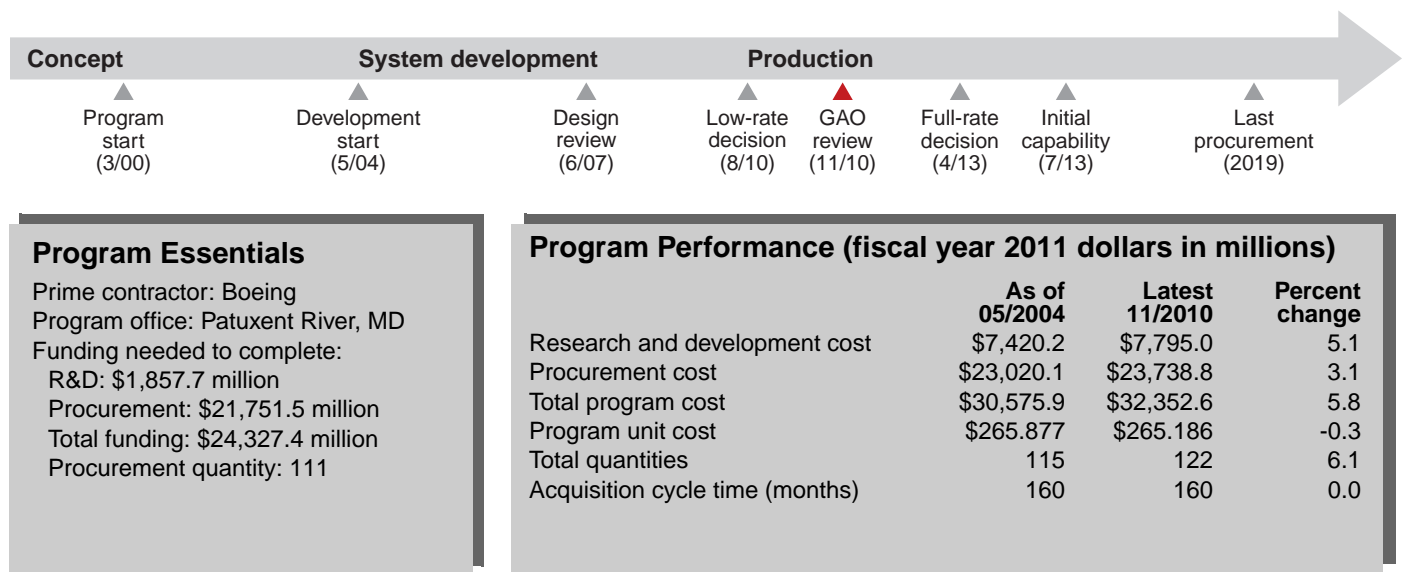


## P-8A Poseidon

The Navy's P-8A Poseidon is a Boeing 737 commercial derivative that will replace the P-3C Orion. Its primary roles are antisubmarine warfare; antisurface warfare; and intelligence, surveillance, and reconnaissance. The P-8A is a part of a family of systems that share the integrated maritime patrol mission and support the Navy's maritime warfighting capability. The program plans to field capabilities in three increments. We assessed increment one.



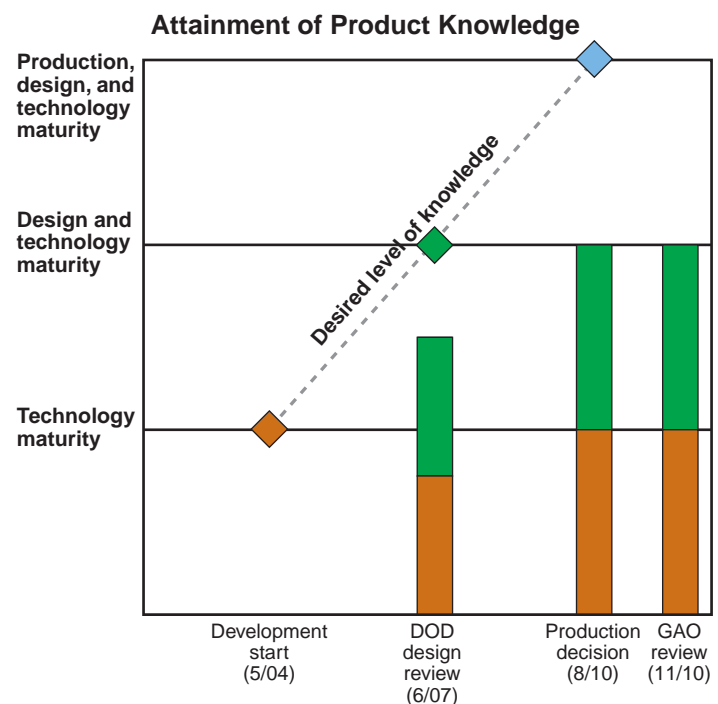
Source: U.S. Navy.



### Program Essentials

Prime contractor: Boeing  
 Program office: Patuxent River, MD  
 Funding needed to complete:  
 R&D: \$1,857.7 million  
 Procurement: \$21,751.5 million  
 Total funding: \$24,327.4 million  
 Procurement quantity: 111

The P-8A entered production in August 2010 with mature technologies and a stable design. The program completed a production readiness review in January 2010 and demonstrated its airframe manufacturing processes on a commercial line prior to the production decision. However, several parts of the P-8A, including the sonobouy launcher, auxiliary fuel tanks, and a new fuel tank safety system, have manufacturing readiness levels that are lower than recommended for the start of production. The airframe on the P-8A program has been designated as a commercial item. The Defense Contract Audit Agency has expressed concern about the designation because of the extent of the modifications being made to the aircraft. In addition, according to the program office, the Defense Contract Management Agency has cited limited access to commercial production facilities as a concern.





## **P-8A Program**

### **Technology and Design Maturity**

The P-8A entered production in August 2010 with mature technologies and a stable design. An independent technology readiness assessment of the program was conducted in December 2009 to support the production decision. The assessment identified one current critical technology, the hydro-carbon sensor, and rated it mature. The sensor has been tested in ground-based applications, but has not been demonstrated in an aircraft. While the ESM digital receiver was considered a critical technology during development, program officials stated that this technology was no longer identified as such because it is mature and has been demonstrated on the E/A-18G. However, no formal ESM flight testing has been conducted on the P-8A. According to the program office, another formerly identified critical technology, the sonobouy launcher, is scheduled to begin testing in a realistic environment in fiscal year 2011.

### **Production Maturity**

The critical manufacturing processes for the P-8A airframe are proven, but manufacturing readiness levels are lower than recommended for the start of production. The P-8A program completed a production readiness review in January 2010 and demonstrated its critical airframe manufacturing processes on a commercial line prior to its August 2010 production decision. The airframe is being procured as a commercial item and has stable production processes that support production rates in excess of 32 airframes per month. However, several parts of the P-8A, including the sonobouy launcher, auxiliary fuel tanks, and new fuel tank safety system are currently assessed at manufacturing readiness levels that are lower than those recommended for the start of production.

### **Other Program Issues**

The P-8A airframe has been designated as a commercial item. As a result, the contractor is not required to submit cost or pricing data to the government. According to the Navy, it weighed the assumed cost and benefits before making the commercial item designation. The Defense Contract Audit Agency has expressed concern about the designation because of the extent of the modifications being made to the aircraft, which include an estimated \$460 million in nonrecurring

engineering. In addition, according to the program office, both the Office of the Secretary of Defense and the Defense Contract Management Agency (DCMA) have expressed concerns about the limited access to production facilities and limited surveillance of aircraft parts afforded by the commercial item designation.

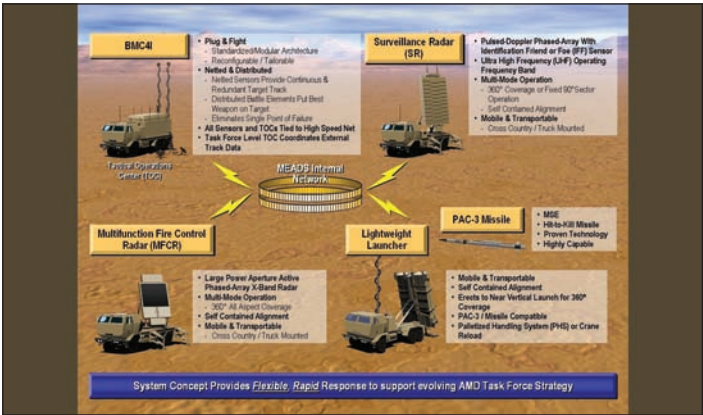
Prior to entering production, an operational assessment of the P-8A found that the system demonstrated the expected level of maturity or exceeded all test thresholds. The assessment was conducted in the program's Weapon System Integration Laboratory (WSIL) and not with an operationally representative aircraft. The Navy operational testers stated that conducting the operational assessment in the WSIL proved to be useful in determining and evaluating the preliminary risks in the development of the P-8A system, but that characterizing system risks based on this data alone represented a major limitation. According to the Navy testers, subsequent flight tests conducted in June 2010 have been successful with only minor issues observed. Initial operational test and evaluation will begin in 2012.

### **Program Office Comments**

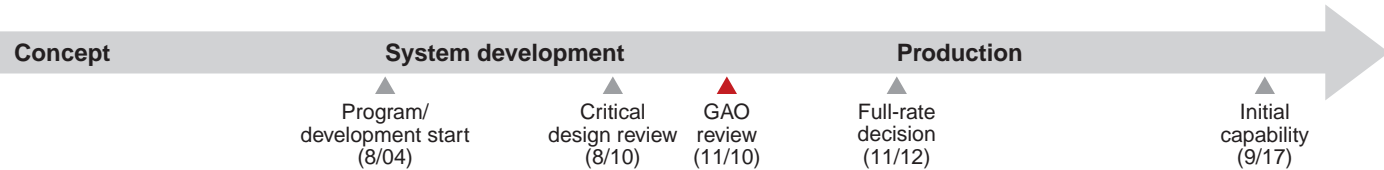
In commenting on a draft of this assessment, the Navy stated that since the P-8A was competitively awarded and more than one offer was received, it did not ask for certified cost or pricing data for the system development and demonstration contract with Boeing Defense, Space and Security (BDS). The Navy further explained that as the airframe is purchased as an interdivisional commercial item, DCMA does not have independent access to inspect it in Boeing Commercial Airplanes' (BCA) facilities. However, the DCMA and the Navy may accompany BDS during BCA selected quality reviews. These events are typical and customary for any customer of BCA. Inspections apply to the aircraft once it reaches the BDS facilities where DCMA can inspect any part of the end product. The Navy also provided technical comments, which were incorporated as appropriate.

PATRIOT/Medium Extended Air Defense System (MEADS) Combined Aggregate Program (CAP) Fire Unit

The Army's PATRIOT/Medium Extended Air Defense System (MEADS) program transitions the PATRIOT missile system to MEADS. MEADS is intended to provide low-to-medium-altitude air and missile defense to counter, defeat, or destroy tactical ballistic missiles, cruise missiles, or other air-breathing threats. MEADS is being developed by the United States, Germany, and Italy. We assessed the MEADS fire unit, which includes launchers, radars, a battle management component, and reloaders. We did not assess the PATRIOT missile.



Source: U.S. Army.



**Program Essentials**

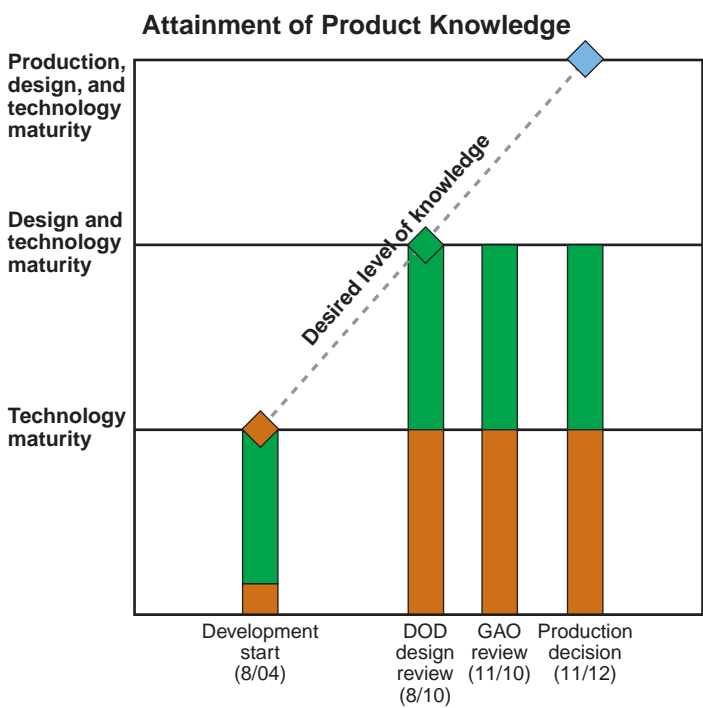
Prime contractor: MEADS International  
Program office: Huntsville, AL  
Funding needed to complete:  
R&D: \$2,820.2 million  
Procurement: \$13,693.0 million  
Total funding: \$16,513.2 million  
Procurement quantity: 48

**Program Performance (fiscal year 2011 dollars in millions)**

	As of 08/2004	Latest 12/2009	Percent change
Research and development cost	\$5,229.5	\$4,820.3	-7.8
Procurement cost	\$13,847.8	\$13,693.0	-1.1
Total program cost	\$19,077.3	\$18,513.3	-3.0
Program unit cost	\$397.444	\$385.694	-3.0
Total quantities	48	48	0.0
Acquisition cycle time (months)	157	157	0.0

The cost, schedule, quantity, and funding data are for the MEADS fire unit.

The MEADS program completed a system-level critical design review in August 2010 with its technologies mature and design stable. The MEADS member nations held a program review in October 2010, according to officials, to decide whether or not to continue with the program and whether or not to modify the system to use a unified battle management control system being developed by the Army's Integrated Air and Missile Defense program. If the Army and member nations decide to use the new unified battle management control system, the MEADS program will require increased time and funding to develop, field, and integrate this system into the existing fire unit software and hardware. The MEADS program is expected to be rebaselined following the program review if the decision is made to continue it.



## **PATRIOT/MEADS CAP Fire Unit Program**

### **Technology Maturity**

All five of the MEADS critical technologies—launcher electronics, multifunction fire control radar exciter, multifunction fire control radar transmit/receive module, slip ring, and spray cooling system—are mature.

### **Design Maturity**

The MEADS program completed its system-level critical design review in August 2010 and its design is stable. At critical design review the program had released 93 percent of the total expected design drawings across the five major end items. The MEADS battle management, command, control, communications, computer, and intelligence (BMC4I) software and hardware was the only major end item with less than 90 percent of its drawings released. Only 76 percent of BMC4I drawings were releasable by the design review because, according to program officials, one of the international partners came in with a late request to change the collapsible roof design to a fixed roof. As of December 2010, the program has released 98 percent of the expected drawings for the BMC4I and 98 percent across the five major end items.

### **Other Program Issues**

The MEADS member nations held a program review in October 2010, according to officials, to decide whether or not to continue with the program and if so, which battle management system to use—the current MEADS BMC4I tactical operations center or the Army's Integrated Air and Missile Defense Battle Command System (IBCS). This program decision was postponed until December 2010. The Army plans to use IBCS to control and manage sensors and weapons, such as PATRIOT and the Joint Land-Attack Cruise Missile Defense Elevated Netted Sensor System, and support the engagement of air and missile threats. However, the MEADS BMC4I is further along in its development than the IBCS, which entered system development in December 2009. As a result, the MEADS program would require increased time and funding to develop, field, and integrate the IBCS into the existing fire unit software and hardware, if the decision is made to use it.

The MEADS program is expected to be rebaselined following the program review. MEADS officials expect the program's design and development phase to be extended by 18 months due in part to issues with BMC4I and sensor requirements and an underestimation of the sensor development effort that delayed the program's critical design review. Program officials stated that the increased cost associated with the schedule extension is expected to be shared among the three member nations. Details regarding the schedule extension and its effect on the program were not available as negotiations had not begun among the member nations. According to the program's Selected Acquisition Report, the MEADS contract was expected to be amended in the first quarter of fiscal year 2011 to incorporate any programmatic changes.

The MEADS program is at risk of not meeting several technical performance measures, including assembly, disassembly, and emplacement times, especially in extreme temperatures. According to officials, the Army has approved a request for relief for several system performance specifications related to the transportability of various components on C-130 aircraft as well as CH-47 and CH-53 helicopters. The MEADS program faces other transportability challenges as well because the vehicles used to move the system do not meet all NATO road requirements.

### **Program Office Comments**

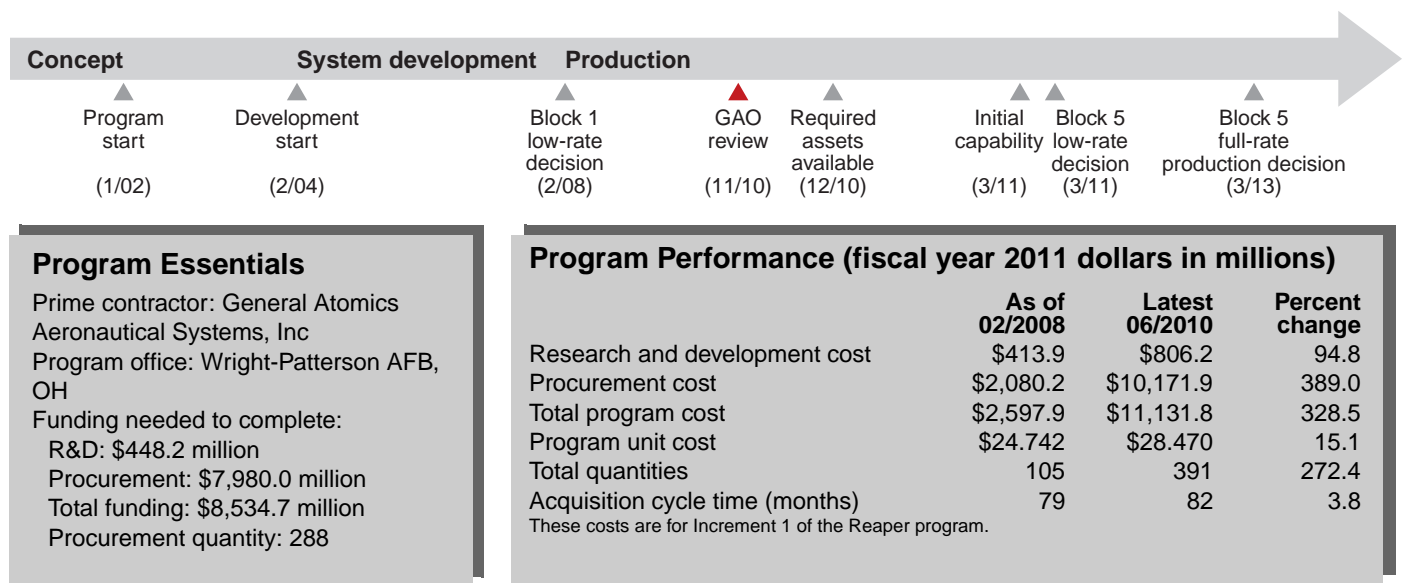
In commenting on a draft of this assessment, program officials noted that the MEADS program is over 6 years into development, that fabrication is well underway, and that initial major end-item deliveries would begin in December 2010. They stated that integration and testing activities are planned to start during calendar year 2011. While the United States is still planning to use the IBCS, the international partners are not, and a program decision is still anticipated by the end of December 2010. Program officials concluded that requirements satisfaction, software maturity, and cost growth continue to be concerns. The program also provided technical comments, which were incorporated as appropriate.

## Reaper Unmanned Aircraft System

The Air Force's MQ-9 Reaper is a multirole, medium-to-high-altitude endurance unmanned aerial vehicle system capable of flying at higher speeds and higher altitudes than its predecessor, the MQ-1 Predator A. The Reaper is designed to provide a ground-attack capability to find, fix, track, target, engage, and assess small ground mobile or fixed targets. Each system consists of four aircraft, a ground control station, and a satellite communications suite. We assessed increment 1, which consists of two configurations, Block 1 and Block 5.



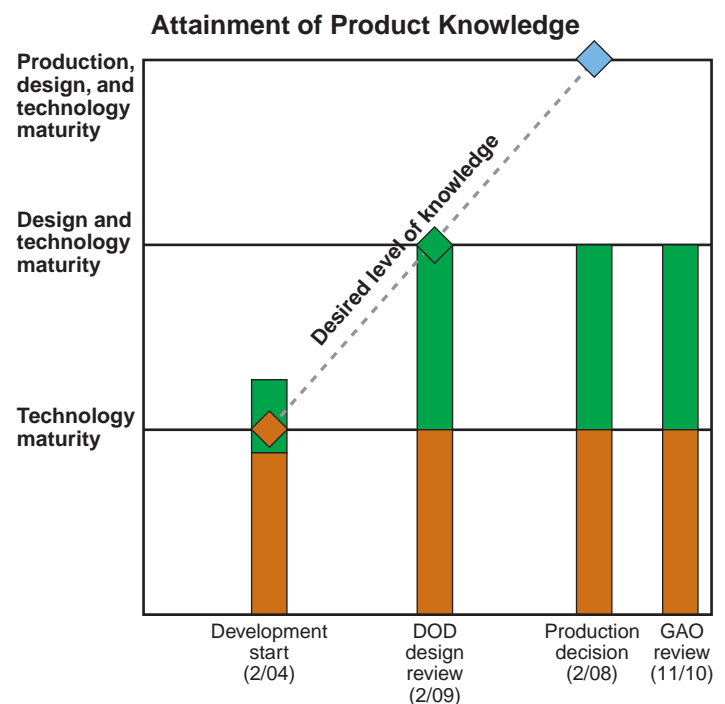
Source: U.S. Air Force.



### Program Essentials

Prime contractor: General Atomics Aeronautical Systems, Inc  
 Program office: Wright-Patterson AFB, OH  
 Funding needed to complete:  
 R&D: \$448.2 million  
 Procurement: \$7,980.0 million  
 Total funding: \$8,534.7 million  
 Procurement quantity: 288

The Block 1 Reaper is in production with critical technologies that are mature and a design that is stable. We did not assess its production maturity. The MQ-9 program plans to make numerous enhancements in Block 5, including system power increases, modernized crew stations, and improvements to the primary data link. The program office judged these improvements to be technologically mature, but they still must be integrated and tested on the MQ-9 system. Total aircraft quantities have increased more than 500 percent since fiscal year 2007 and the program is incorporating several urgent operational needs from the warfighter. Although the Reaper's initial operational testing was completed in August 2008, full-up testing of two key performance parameters was delayed to November 2012 during Block 5 testing. The Air Force plans to begin development of Increment 2 in late fiscal year 2012.



## Reaper Program

### Technology Maturity

The Reaper's Block 1 critical technologies are mature. The Air Force has identified numerous technology enhancements for Block 5 that are expected to improve the capability of existing onboard subsystems and ground control stations. These enhancements include power increases, radar and ground control station upgrades, a secure data link, and heavyweight landing gear. The program office judged these improvements to be technologically mature, but they still must be successfully integrated and tested on the MQ-9 system. For example, the encryption of the data using the primary data link increases the time to transmit data. These transmission delays could result in hard landings, which may damage the aircraft. The program office is currently evaluating a range of hardware and software solutions to this problem and plans to test them operationally in November 2012. The program plans to undergo a Block 5 technology readiness assessment in support of its low-rate production decision by March 2011.

### Design Maturity

According to the program office, the Block 1 Reaper design is stable and all engineering drawings have been released. The MQ-9 program plans to conduct a formal critical design review on the Block 5 configuration in December 2010. At that time, it expects to know the number of additional drawings needed for this configuration.

### Production Maturity

We did not assess production maturity because the MQ-9 program does not use statistical process controls. The program uses other quality control measures such as scrap, rework, and repair to track product quality. The program is in production and contracted for 103 aircraft. The contractor has a continuous improvement program that includes manufacturing process goals, which are updated as they are met. The Air Force has also conducted several manufacturing reviews of the contractor's facilities and determined that the production capacity is sufficient to meet the expected demand.

### Other Program Issues

Since its inception, the MQ-9 program has followed a concurrent development and production strategy in order to respond to urgent operational needs. Total

aircraft quantities have increased by over 500 percent since fiscal year 2007 and the system's performance requirements have continued to change. In addition to the Block 5 capability upgrade, the program is also incorporating several urgent operational requirements from the warfighter, such as data link encryption, wide area / high resolution surveillance, and a capability to detect dismounted soldiers. Meeting these demands has put a stress on the program's resources. A recent systems engineering review noted that the contractor's resources have been overburdened by the need to balance software development, support ongoing operations, and enhance system capability. It also found that the Reaper program lacks sufficient software metrics to allow proper developmental resource and schedule planning.

The Block 1 Reaper completed initial operational testing in August 2008. Testers found that it was effective in the killer role, but problems associated with radar and the network prevented them from evaluating the hunter and net-ready capability. To enable testers to fully evaluate the hunter capability, the Air Force is upgrading the radar's ground moving target indicator and target recognition/classification capability, and integrating the radar into the crew station. Full-up testing of these capabilities was delayed and will be completed during the Block 5 initial operational testing, scheduled for November 2012.

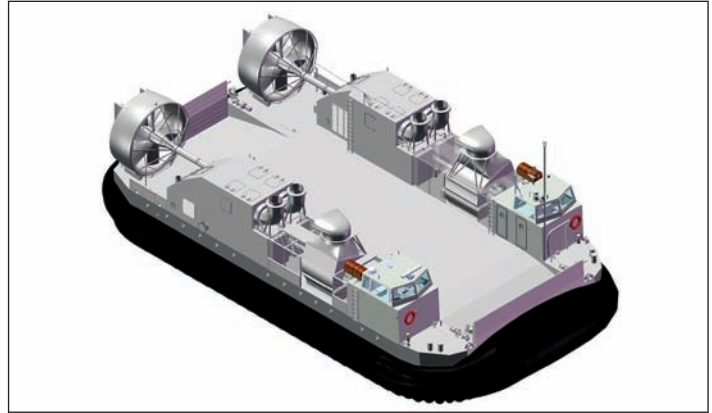
The Air Force plans to begin development of increment 2 of the MQ-9 Reaper in late fiscal year 2012. This increment will include the small diameter bomb, an automatic take-off and landing capability, a deicing system, and national airspace certification.

### Program Office Comments

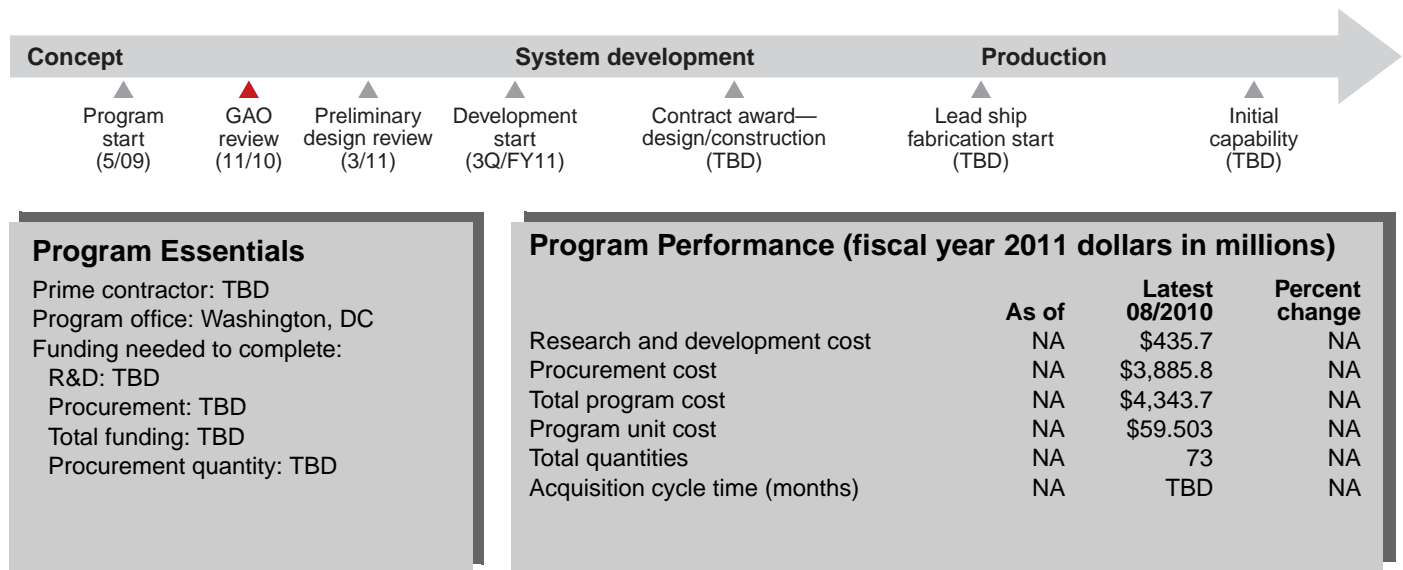
In commenting on a draft of this assessment, the Air Force provided technical comments, which were incorporated as appropriate.

## Ship to Shore Connector (SSC)

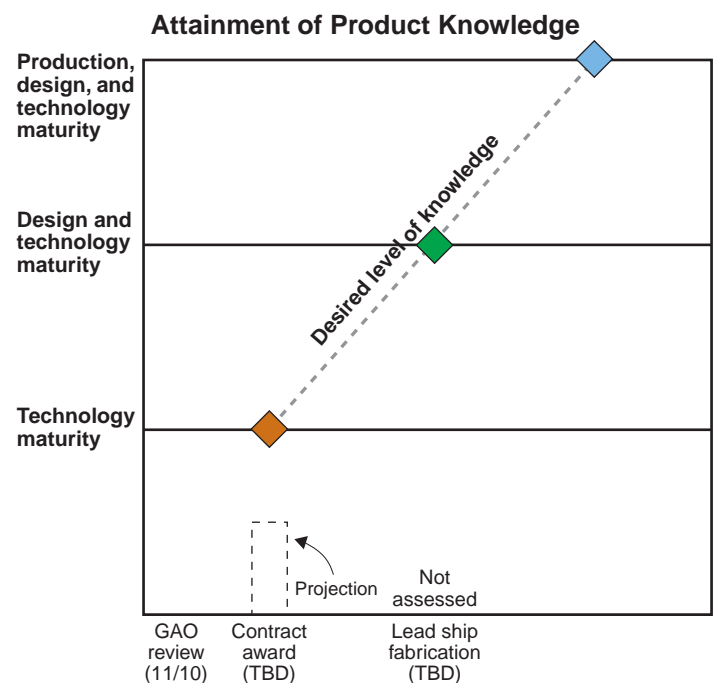
The Navy's Ship to Shore Connector is expected to provide transport of personnel, weapon systems, equipment, and cargo from ships to the shore. SSC is the replacement for the Landing Craft, Air Cushion (LCAC), which is facing the end of its service life. The SSC will deploy in existing and planned Navy well deck amphibious ships and will be used for assault and nonassault operations. It is expected to operate independent of tides, water depth, underwater obstacles, ice, mud, or beach conditions.



Source: U.S. Navy.



The SSC program plans to award the detail design and construction contract for the lead ship in fiscal year 2011 with all five potential critical technologies nearing maturity or mature. According to the program office, the SSC will be the first government-led Navy ship design in 14 years. Aligned with goals from Office of the Under Secretary of Defense for Acquisition, Technology and Logistics' efficiency initiative, the Navy is focused on balancing costs with capabilities during the technology development phase in order to formulate requirements that are technically achievable within known fiscal constraints. The Under Secretary has also emphasized affordability and encouraged programs to make tradeoffs in order to stay within the established costs for the program.





## **SSC Program**

### **Technology Maturity**

The SSC program expects all five potential critical technologies to be mature or nearing maturity by the time the detail design and construction contract for the lead ship is awarded. The program has identified five critical technologies—the aluminum buoyancy box, gas turbines, fire suppression system, composite shaft, and composite lift fan. According to the program office, some components of these technologies are already in use in the Navy fleet. For instance, several potential SSC candidate engines are used in the aircraft industry today. According to program officials, there are risks associated with readying them for ships. The aluminum chosen is the same alloy that is in use on the second Littoral Combat Ship, and composites are used throughout the Navy fleet, including on the LCACs. The Navy plans to release the request for proposal for the detail design and construction of the SSC in the first quarter of 2011.

### **Other Program Issues**

According to Navy officials, the SSC is the first government-led Navy ship design in 14 years. The Under Secretary of Defense for Acquisition, Technology and Logistics has emphasized affordability and encouraged programs in the technology development phase to make tradeoffs in order to stay within the established costs for the program. Accordingly, the Navy is focusing on producing a design that reduces maintenance costs and balances performance requirements against life-cycle costs. The SSC is expected to have greater lift, a lower fuel consumption rate, and less expected maintenance than the LCAC. The Navy plans to achieve this through a series of design changes, including the extensive use of composite materials, a simpler and more efficient drive train, and more powerful, fuel-efficient engines. In validating the SSC's key performance parameters in June 2010, the Joint Requirements Oversight Council (JROC) required the program to return to the JROC if costs exceed 10 percent of the approved program baseline.

### **Program Office Comments**

In commenting on a draft of this assessment, the Navy stated that the JROC validated the SSC requirements that have defined the SSC technical design parameters within the technology

development phase. The Navy noted that the program is considered low risk, technically sound, and is postured for events leading up to development start, program initiation, and release of a request for proposal for detail design and construction and entry into the engineering and manufacturing development phase. The Navy also provided technical comments that were incorporated as appropriate.

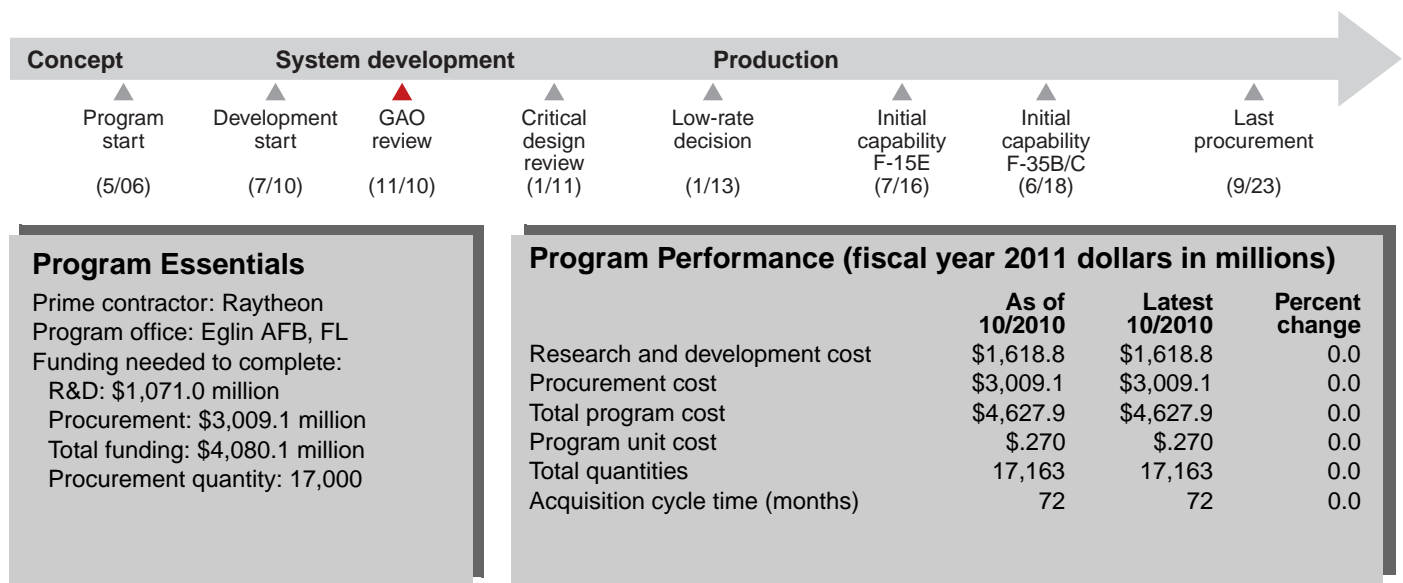


## Small Diameter Bomb (SDB), Increment II

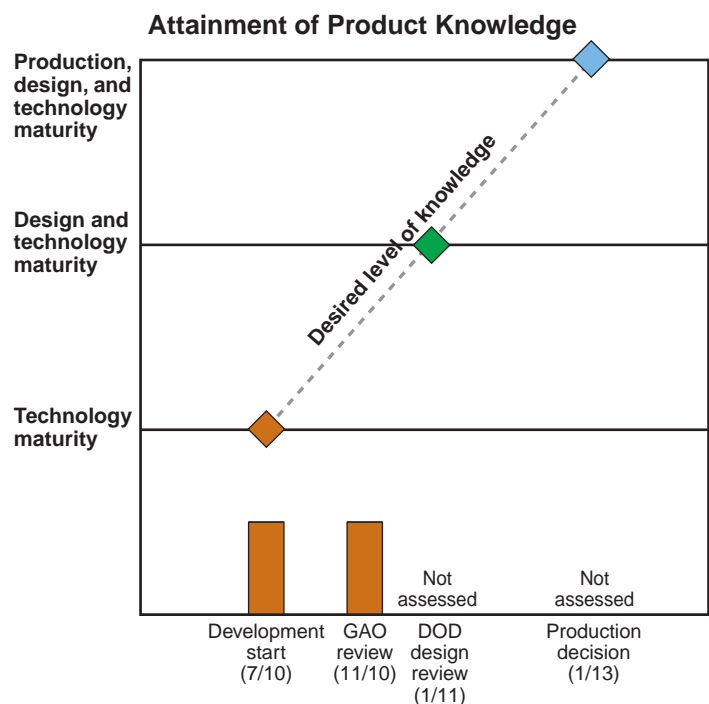
The Air Force's Small Diameter Bomb (SDB) Increment II is planned to provide attack capability to moving or stationary mobile targets in adverse weather from standoff range. It combines radar, infrared, and semi-active laser sensors in a multi-mode seeker to acquire, track, and engage targets. It uses a weapons data link from host aircraft as well as GPS and an inertial navigation system to achieve accuracy. SDB II will integrate with the F-15E and the Navy and Marine Corps Joint Strike Fighter, and with other aircraft, such as the F-22A.



Source: © 2010 Raytheon Company.



The SDB II program entered system development in July 2010 with all four of its critical technologies nearing maturity. In an April 2010 technology readiness assessment, each technology was found to need additional development to demonstrate the required level of maturity for operational use. While some of the SDB II technologies are being utilized in other systems, they are being applied in new ways on this program. In addition, the integration of those technologies into the constrained SDB II design is a risk for the current development schedule. Further, the program already faces funding shortfalls. When the program was approved to enter development, it was granted a waiver from the requirement to provide full funding. The funding shortfall was estimated to be about 22 percent of the required funding over the life of the program.



## **SDB II Program**

### **Technology Maturity**

The SDB II program entered system development in July 2010 with all four of its critical technologies nearing maturity. In April 2010, an independent technology readiness assessment found that the SDB II data link, payload (warhead), seeker, and target classifier had been demonstrated in a relevant environment. The assessment team based their conclusions on modeling and simulation, as well as captive flight, static and dynamic warhead, and other testing methods. Each technology was found to need additional development to demonstrate the required level of maturity for operational use. In addition, while each of these technologies has been fielded in one or more weapon systems, they are being applied in new ways on this program and must be integrated into the constrained SDB II design. The data link is a new application of an existing technology and will require a tremendous leap forward in packaging. The payload (warhead) will be used in a way on SDB II that is beyond its current demonstrated capability, and fuze development has been and continues to be a problem. The seeker combines proven sensor technologies, but in a smaller design. The target classifier is a new technology in a weapon system context. Finally, Joint Strike Fighter integration issues represent a substantial risk for the program and the Navy because the aircraft may not be available for environmental and integration testing until after the SDB II has completed its initial development. The environments of the Joint Strike Fighter may cause a re-design of a portion of the weapon or limitations in the weapon's employment.

### **Design Maturity**

The SDB II program held its critical design review in January 2011. We could not assess SDB II design maturity because data on design drawings were not available. As an entrance criteria for holding the design review, the program had planned to determine if 95 percent of the system's drawings were completed and under configuration control. Program officials stated that it appeared the design as presented is capable of achieving the desired requirements for the system. If the program's post-critical design review assessment is successful, the contractor will be cleared to start building hardware for the SDB II program.

### **Other Program Issues**

In July 2010, the Under Secretary of Defense for Acquisition, Technology and Logistics approved the SDB II to enter engineering and manufacturing development. The program will use a fixed-price incentive contract for this phase of the program. The Under Secretary also approved an aggressive procurement schedule in an effort to promote affordability and productivity. However, the acquisition decision memo that outlined these decisions stated that it will be a challenge to execute this strategy because of DOD's track record of procuring weapons at less than economically beneficial rates due to budget pressures. In addition, the program already faces funding shortfalls. When the program was approved to enter development, it was granted a waiver from the requirement to provide full funding. The program is not currently funded to the Air Force's cost estimate or its current acquisition program baseline. The shortfall was estimated to be about 22 percent of the required funding over the life of the program.

### **Program Office Comments**

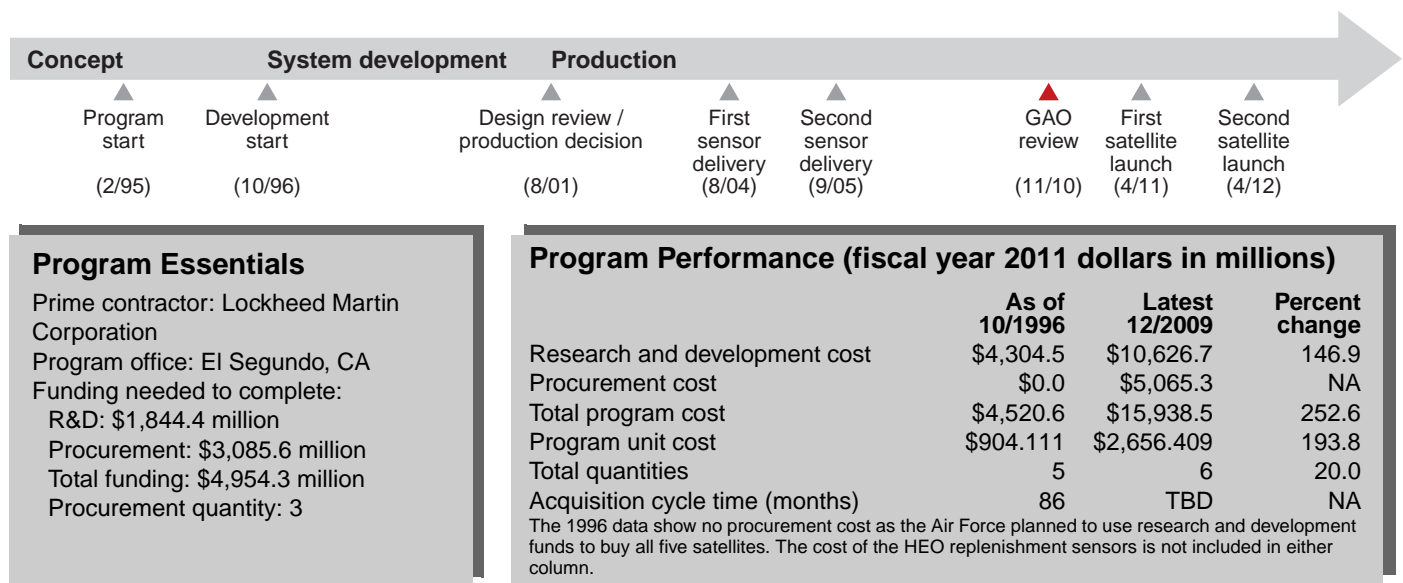
The program office offered technical comments, which were incorporated as appropriate.

## Space Based Infrared System (SBIRS) High Program

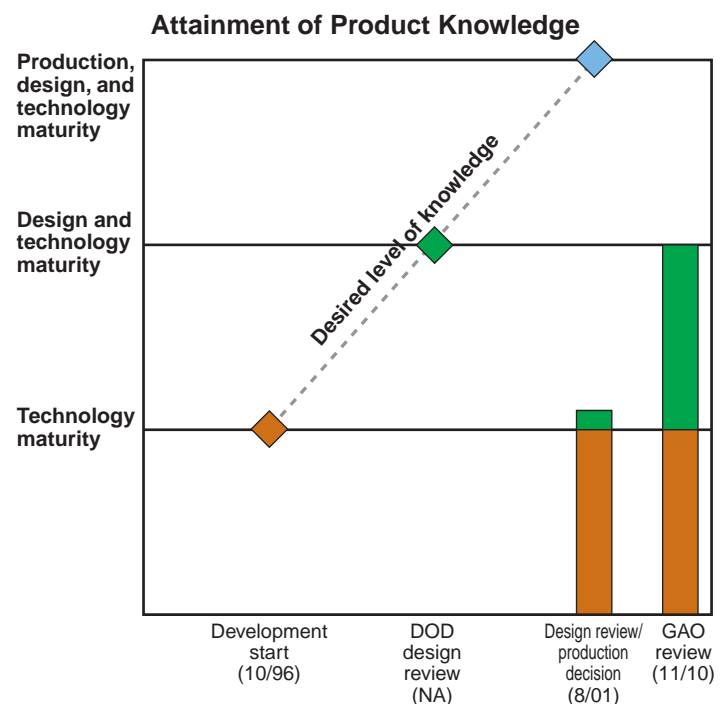
The Air Force's SBIRS High satellite system is being developed to replace the Defense Support Program and perform a range of missile warning, missile defense, technical intelligence, and battlespace awareness missions. SBIRS High consists of four satellites in geosynchronous earth orbit (GEO) plus two replenishment satellites, two sensors on host satellites in highly elliptical orbit (HEO) plus two replenishment sensors, and fixed and mobile ground stations. We assessed the space segment and made observations about the ground segment.



Source: © 2007 Lockheed Martin Corporation.



According to the program office, SBIRS High critical technologies are mature, its design is stable, and its manufacturing processes have been proven; however, continued difficulties with flight software development could add to the program's cost overruns and schedule delays. According to the program office, significant progress has been made on flight software testing. However, various subsystem- and system-level qualification testing remains and the Defense Contract Management Agency (DCMA) has reported that the effort required to finalize the flight software is likely to further delay the launch date of the first GEO satellite. The program office's best-case estimate is that the first GEO satellite will launch in April 2011—4 months later than previously estimated and roughly 9 years later than originally planned.



## **SBIRS High Program**

### **Technology Maturity**

According to the SBIRS High program office, all three critical technologies—thermal management, onboard processing, and the infrared sensor—are mature.

### **Design Maturity**

The SBIRS High hardware design appears stable. According to the program office, over 99 percent of the total expected design drawings are releasable. Functional testing of the first GEO spacecraft in 2009 revealed solder fractures on some hardware components, which contributed to satellite delivery delays. The program disassembled and tested these components and determined that redesign was unnecessary and they were suitable for use as-is.

Hosted HEO sensors are currently on-orbit, and program officials report that they are operational. The program plans to buy replenishment sensors that will differ only slightly in design. According to the program office, the design changes will address parts obsolescence and electromagnetic interference issues that affected the original sensors. Those interference issues led the program to issue waivers to accept the original sensors for operational use, even though they did not meet all the program's specifications. Replenishment sensors are scheduled for delivery to the host for integration in fiscal years 2012 and 2015.

### **Production Maturity**

According to the program office, the manufacturing processes for SBIRS High are proven since the first and second GEO satellites and the first two HEO sensors have been built.

### **Other Program Issues**

The estimated cost of the program continues to grow, and its schedule is at risk for further delays. DCMA projects nearly \$600 million in cost overruns at contract completion, more than twice the amount reported last year. Additional contract cost increases and schedule delays are expected due in part to the continued underestimation of the effort required to finalize and test the flight software. The program office is working to rebaseline the SBIRS High contract cost and schedule estimates for the sixth time; it will then revise its acquisition program baseline to more realistic cost and schedule goals.

Developing the complex flight software subsystem designed to monitor the health and status of the spacecraft has already caused multiple delays, and DCMA has reported that the remaining software effort will likely further delay the launch date of the first GEO satellite. According to the program office, significant progress has been made on flight software testing, but various subsystem- and system-level qualification testing remains. For example, the fault management system, which has caused delays in the past, was scheduled to undergo testing in late 2010 to determine whether the system will perform as expected. According to DCMA, these tests had to be completed by the end of 2010 for the program to have a realistic chance of launching the first GEO satellite in April 2011—the program office's best-case estimate.

According to program officials, the development of the SBIRS High ground system is on track, and the system will be available to process the data generated from the first GEO satellite when it reaches its orbit. If the first GEO satellite launches in April 2011, program officials expect that satellite data will be certified for use in missile warning operations by November 2012.

### **Program Office Comments**

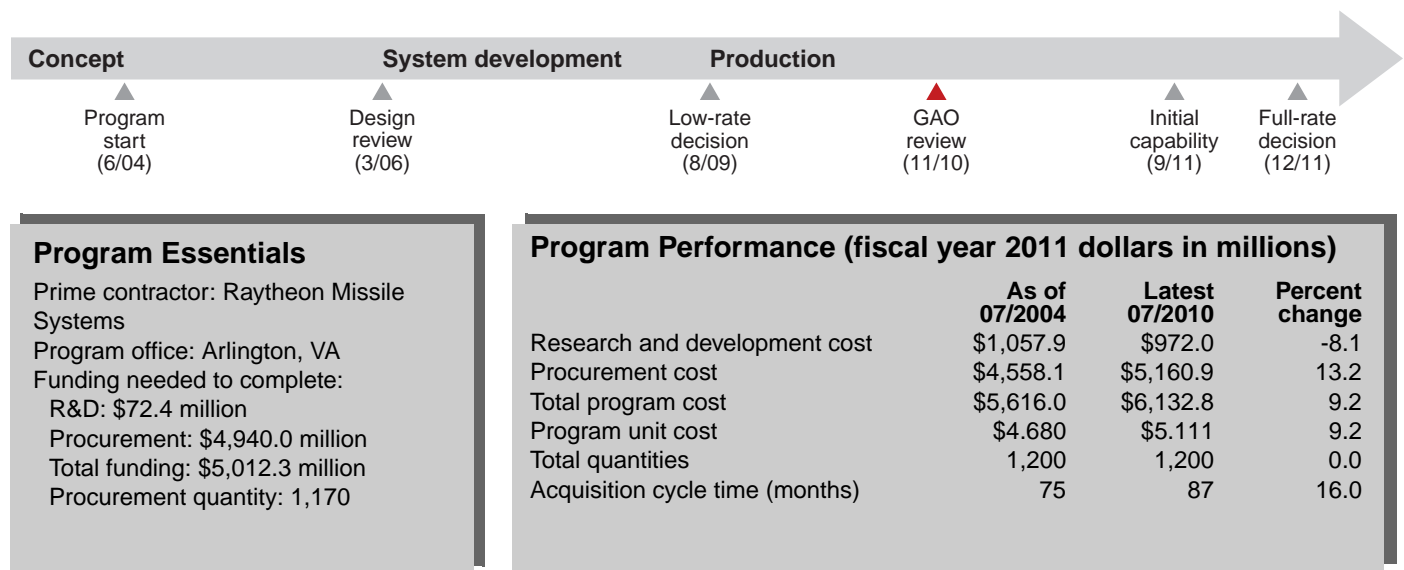
In commenting on a draft of this assessment, the program office stated that the first GEO satellite successfully completed all integration testing. In mid-December 2010, the final system-level test was completed, and installation began of components, such as solar array wing assemblies and a deployable light shade. Flight software run-for-record activities for the first GEO satellite are expected to be completed in February, supporting the start of launch processing in March. Independent review teams verified that an April 2011 launch is achievable. Ground software required for launch has been verified. The follow-on production contract procures the third and fourth GEO satellites completing the original SBIRS constellation, plus two HEO replenishment payloads; it was definitized in June 2010, and values roughly \$3 billion. The program office also provided technical comments, which were incorporated as appropriate.

## Standard Missile-6 (SM-6) Extended Range Active Missile (ERAM)

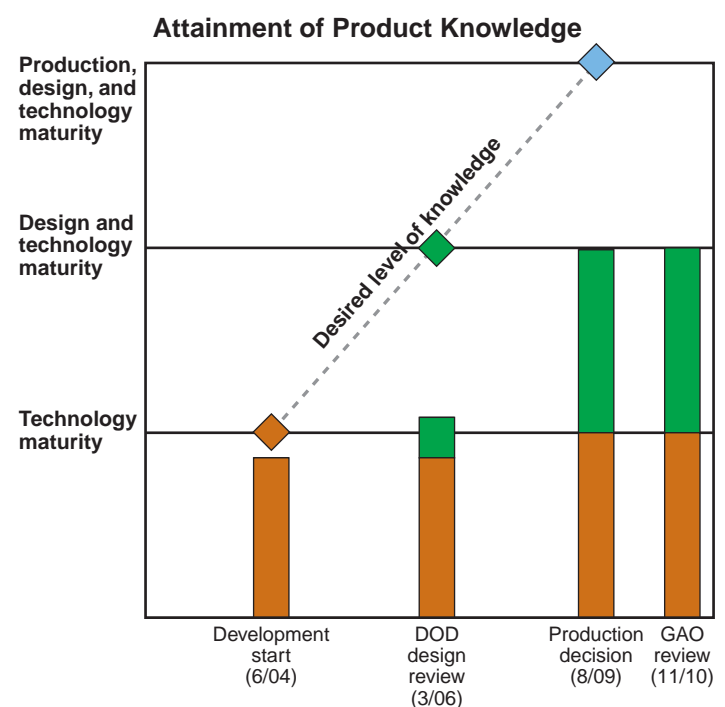
The Navy's Standard Missile-6 (SM-6) is a surface-to-air missile launched from Aegis destroyers and cruisers to provide ship self-defense, fleet area defense, and theater air defense. Combining legacy Standard Missile (SM) and Advanced Medium-Range Air-to-Air Missile (AMRAAM) hardware and technology, SM-6 will allow for over-the-horizon engagement, improved capability at extended ranges, and capability to receive in-flight updates from Aegis ships. SM-6 Block 1 is in production. Follow-on blocks will be developed to meet future threats.



Source: Raytheon Missile Systems.



The SM-6 program's concurrent testing and production strategy puts the program at increased risk of cost growth and schedule delays. The program is in low-rate production with 30 missiles under contract and deliveries expected to begin in March 2011. However, the program has not completed developmental testing to prove that the design meets performance and reliability requirements, and the risk of design changes remains. Recent test failures have increased the risk that unexpected design changes could result in costly rework for the 30 missiles already under contract and schedule delays. To receive approval to enter full-rate production, the program must successfully complete flight testing, demonstrate reliability, and achieve production maturity. Full testing of SM-6 capabilities will not occur until after full-rate production is well underway.



## **SM-6 Program**

### **Technology and Design Maturity**

According to the program office, all SM-6 critical technologies were mature and its design was stable by its August 2009 production decision; however, the program has not completed developmental testing to prove that the design will meet performance and reliability requirements. Until developmental testing is completed, the risk of design changes remains. Land-based developmental testing was successfully completed in 2009. However, sea-based developmental testing was suspended in May 2010 after two test failures. According to program officials, the failures did not result in hardware design changes and developmental testing is scheduled to resume in January 2011. According to an official from DOD's Office of the Director, Operational Test and Evaluation, the program's limited number of developmental test flights leaves little margin for error.

### **Production Maturity**

The SM-6 is in low-rate production with 30 missiles under contract and deliveries expected in March 2011. We could not assess production maturity because the program did not provide statistical process control data. However, prior to production start, the program demonstrated a maturity level sufficient to proceed with low-rate production. To obtain approval to begin full-rate production, the program must achieve production maturity, successfully conclude at-sea developmental and operational flight testing, and demonstrate reliability. However, the program and DOD's Director of Operational Test and Evaluation have not yet agreed to the flight reliability metrics and failure definitions that will be used to assess the program.

### **Other Program Issues**

The SM-6 program's concurrent testing and production strategy puts the program at increased risk of cost growth and schedule delays if unexpected design changes are required as a result of testing. In 2009, the program obtained approval from the Under Secretary of Defense for Acquisition, Technology and Logistics to begin low-rate initial production of up to 19 missiles before completing developmental testing. To minimize the risks inherent in this approach, the Under Secretary required the program to complete developmental

testing and obtain approval prior to awarding subsequent contracts. Despite the test failures that led to the suspension of at-sea developmental testing in May 2010, the Under Secretary approved low-rate production of an additional 11 missiles and the procurement of long-lead materials for the remaining 59 low-rate missiles.

SM-6 capabilities will not be fully tested until after full-rate production is well underway. SM-6 is a key pillar of the Naval Integrated Fire Control-Counter Air System—a system of systems designed to extend the battle space over the horizon. A developmental version of the integrated fire control capability was demonstrated in 2009; however, it is not scheduled to be demonstrated at-sea until fiscal year 2014. The program plans to have three of four full-rate production lots under contract by that time. According to the program office, the Office of the Secretary of Defense decided the SM-6 should be fielded in advance of the Naval Integrated Fire Control-Counter Air System to address the Navy's critical shortage of extended range missiles.

### **Program Office Comments**

In commenting on a draft of this assessment, the SM-6 program office disagreed with the GAO assertions that the program's concurrent testing and production strategy puts the program at risk of cost growth and schedule delays; that the program has not completed testing to prove that the design meets performance requirements; and that recent test failures increase the risk of design changes. According to the program office, the program successfully completed reliability demonstration testing and has begun high-accelerated-life testing. In addition, the SM-6 hardware is very mature, and the risk of design changes is minimal. Officials added that full testing of SM-6 using the legacy interface will be completed prior to the full-rate production decision and that flight testing using the integrated fire control interface will take place prior to delivery of the first full-rate production missiles.

### **GAO Response**

Our reviews of DOD weapon systems confirm that fully configured, integrated, production-representative prototypes should be tested before committing to production. The benefits of testing are maximized when the developmental tests are completed prior to a production decision because making design changes after production begins can be both costly and inefficient.

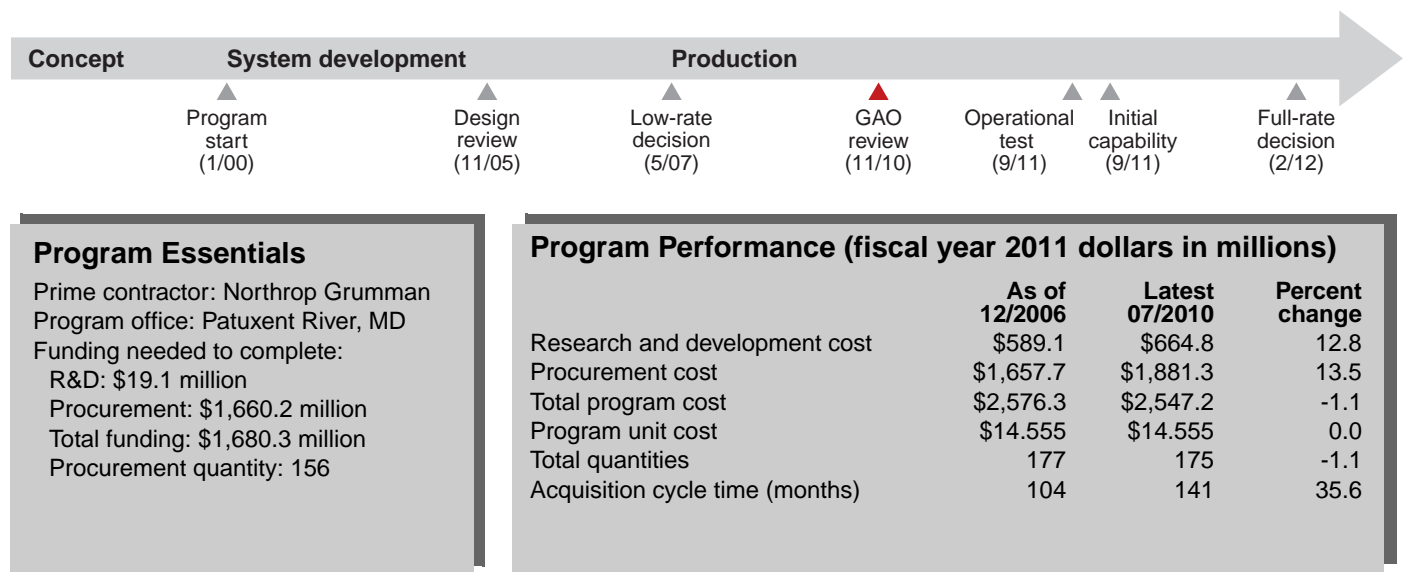


## Vertical Take-off and Landing Tactical Unmanned Aerial Vehicle (VTUAV)

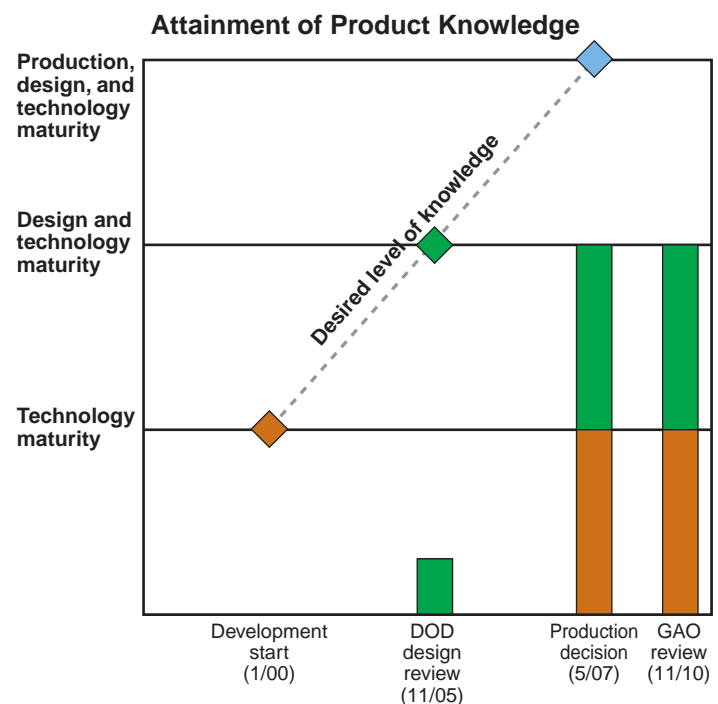
The Navy's VTUAV will provide real-time imagery and data to support intelligence, surveillance, and reconnaissance requirements. A VTUAV system is composed of up to three air vehicles with associated sensors, two ground control stations, one recovery system, and spares and support equipment. The air vehicle launches and recovers vertically, and operates from ships and land. The VTUAV is being designed as a modular, reconfigurable system that supports various operations, including surface, antisubmarine, and mine warfare.



Source: © 2006 Northrop-Grumman Corporation.



The VTUAV is in production, but the program may be at risk for further cost increases and schedule delays as a result of concurrent testing and production. The VTUAV program delayed the start of operational test and evaluation by 2 years to September 2011, due to system reliability and software maturity issues that were discovered during developmental flight testing. During an August 2010 flight test, the operator lost contact with the aircraft, resulting in it entering restricted air space. As a result, the program made changes to the software. In order to keep suppliers producing at a minimum rate until operational test and evaluation is complete, the program increased its low-rate production quantities from 9 to 15. The program plans to achieve initial operational capability in September 2011 and full-rate production in February 2012—almost 2 years later than previously planned.





## **VTUAV Program**

### **Technology Maturity**

The VTUAV relies on common, mature technologies.

### **Design Maturity**

The VTUAV design is still changing as a result of ongoing testing. The program had released all its expected drawings by its May 2007 production decision, but it subsequently made design changes and added drawings to address problems discovered during developmental testing. As of January 2011, 100 percent of the program's total expected design drawings have been released. However, the program is still making changes to the design as a result of concurrent testing and production. The program anticipates 20 changes in the aircraft's design, requiring 60 additional design drawings. The formal evaluation of the system's operational suitability and effectiveness was not completed as anticipated until April 2010. During an assessment of the system on the USS McInerney and subsequent developmental flight tests, the program discovered system reliability and software maturity issues, including a weak communications link and false alarms related to the unmanned system's status. More specifically, during an August 2010 developmental flight test, the operator lost contact with the aircraft, causing it to enter restricted air space. An investigation determined the root cause to be a software design flaw and the program has since made changes to the software. The VTUAV program also delayed the start of operational test and evaluation by 2 years to September 2011. The program now plans to achieve initial operational capability in September 2011 and full-rate production in February 2012—almost 2 years later than previously planned.

### **Production Maturity**

The VTUAV was originally designed as a modified commercial off-the-shelf item. We could not assess production maturity because the program did not require the prime contractor or its supplier base to identify key product characteristics—the first step to implementing production process controls. The program reports that one VTUAV supplier uses statistical process controls to measure elements of blade manufacturing. In addition, the program plans to develop production metrics based on critical safety items and safety of flight inspection criteria to support the full-rate production decision. The program increased its low-rate production quantities

from 9 to 15, in order to keep suppliers producing at a minimum rate until operational test and evaluation is complete.

### **Other Program Issues**

The VTUAV program is currently considering a variety of future capabilities that could be added to the system, including a surface search radar, a signals intelligence package, an enhanced data and communications relay, and weapons. The program office had funding in place in fiscal year 2010 to integrate a surface search radar, but that funding was used to sustain the program when it experienced cost overruns resulting from software issues discovered during developmental testing. Other planned capabilities are currently unfunded. Work on these capabilities will be implemented as subprograms.

### **Program Office Comments**

In commenting on the draft of this assessment, the Navy stated that the VTUAV program has made significant progress in the last year. VTUAV conducted integration testing on the USS Freedom in November 2010, is deployed on the USS Halyburton, is being deployed to Afghanistan as part of the Intelligence, Surveillance and Reconnaissance Task Force, and has been selected by Office of the Secretary of Defense as the interim solution for a classified, maritime-based, intelligence, surveillance, and reconnaissance urgent need requirement.

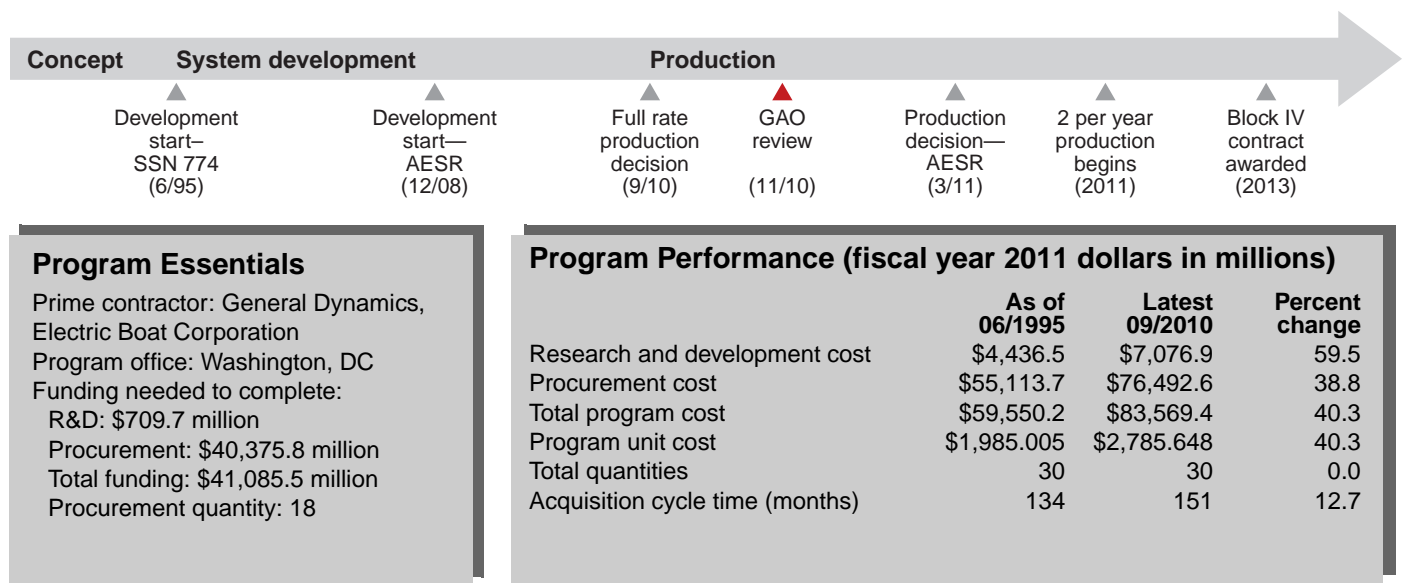
VTUAV experienced a delay in the start of operational evaluation and continues to make incremental strides to satisfy the full capability production document requirements. Software changes to correct problems discovered during developmental testing have accounted for the majority of this schedule delay as any newly discovered software anomaly will delay flight testing until a new software build is released. The operational evaluation completion date is driven by ship availability, and the USS Halyburton is not available until late summer 2011. The Navy also provided technical comments, which were incorporated as appropriate.

## Virginia Class Submarine (SSN 774)

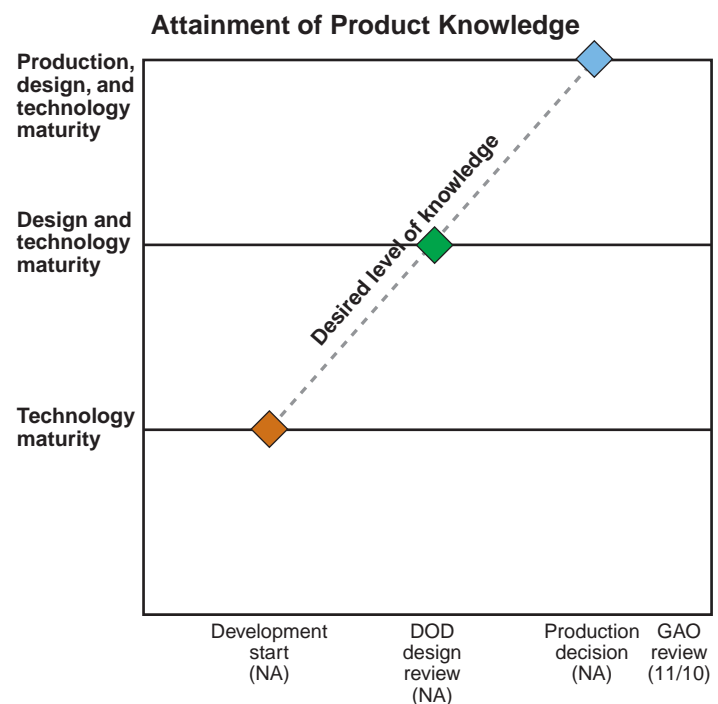
The Navy's Virginia class attack submarine is designed to combat enemy submarines and ships, fire cruise missiles, and provide improved surveillance and special operations support to enhance littoral warfare. The Navy awarded a Block III construction contract in 2008 and has begun construction on the first two hulls. In total, 7 ships have been delivered and 11 more are under contract. The Navy is introducing one new technology to improve system performance. We assessed this technology and made observations on design and production issues.



Source: U.S. Navy.



The Virginia class submarine program was approved to enter full-rate production in September 2010. Construction of the first two Block III submarines has begun, and production of the first hull featuring several affordability-based design changes is underway. The Navy is also working to address quality control and reliability concerns. The Navy will begin buying two submarines per year in fiscal year 2011. It expects to realize its goal of reducing costs to \$2.0 billion (in fiscal year 2005 dollars) per ship by fiscal year 2012 ship procurement and hopes to further decrease the time required to build each ship. The Navy has decided not to pursue two planned technology insertions for the Virginia class, but it is still developing advanced electromagnetic signature reduction (AESR) technology that will be introduced onto existing and new submarines. AESR will begin testing in 2011.



## SSN 774 Program

### Technology Maturity

The Navy has decided not to pursue two planned technology insertions for the Virginia class, but it is still developing advanced electromagnetic signature reduction (AESR) technology that will be introduced onto existing and new submarines. The Navy plans to install AESR—software that monitors and optimizes the submarine’s signature—on ships starting with SSN 782. The software will be installed on earlier ships over time. According to the Navy, AESR prototype testing slipped by more than a year due to non-AESR-related schedule delays, and is scheduled to begin on SSN 778 in September 2011. The Navy decided not to incorporate a conformal acoustic velocity sensor wide aperture array on the ship after it found it would significantly increase, not decrease, life-cycle costs and complicate maintenance. The Navy is still evaluating more affordable sail designs, but according to officials, the larger, flexible payload sail is no longer being considered because the communications requirements that drove the need for more space have been eliminated.

Prior to the program’s full-rate production decision, the Joint Requirements Oversight Council approved a change to three Virginia class key performance parameters. According to the Navy, they determined that the original requirements were unrealistic and would not be worth the cost needed to achieve them. The change will not affect operations.

### Design and Production Maturity

The program was approved to enter full-rate production in September 2010. The Navy will begin buying two ships per year in fiscal year 2011. The Navy expects to achieve its goal of reducing costs to \$2.0 billion (in fiscal year 2005 dollars) per ship by fiscal year 2012 ship procurement and hopes to reduce the time required to build each ship to about 60 months. Navy officials said construction of SSN 784—the first hull incorporating significant cost-reducing design changes—has been underway for approximately 2 years and is progressing well. The Navy expects the first few hulls with this new design to take longer to build, but expects to get back on schedule by the middle of Block III.

### Other Program Issues

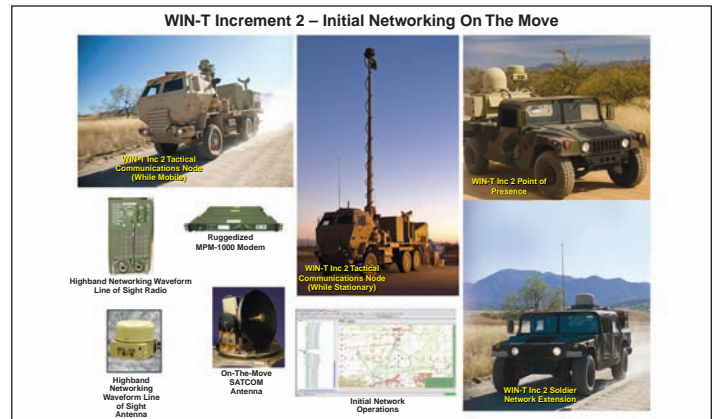
The Navy is working to address quality control and reliability concerns. In November 2009, the Director, Defense Research and Engineering (DDR&E), highlighted several design and reliability-related deficiencies the program needed to address, but concluded they did not preclude the program from moving forward into full-rate production. These deficiencies, which included multiple subsystem failures, multiple “fail to sail” issues, and test aborts, were also cited by the Director, Operational Test and Evaluation, as examples of the pervasive reliability problems that affect DOD systems. DDR&E also noted that the program did not have a reliability measurement or growth program—a best practice. Navy officials told us that plans are in place to mitigate each of these issues. For example, according to the Navy, subsystem problems are being addressed with the vendors and shipyards through changes to installation techniques, engineering changes or redesigns, and evaluations of alternative technologies. Navy officials also told us fail to sail events are not unexpected early in a program and that the Virginia class submarine has not experienced any fail to sail events while deployed. According to Navy and DDR&E officials, problems with a special hull treatment separating from the hull have also been mitigated by changing surface preparation techniques and redesigning coating molds. Delivered hulls will have the coating restored as needed, and more significant restoration can occur during scheduled dry-dockings. According to Navy officials, this issue is not unique to the Virginia class and has not resulted in any operational deficiencies. Navy officials said the shipbuilder has also addressed the torpedo-room manufacturing quality issues that were identified in 2009.

### Program Office Comments

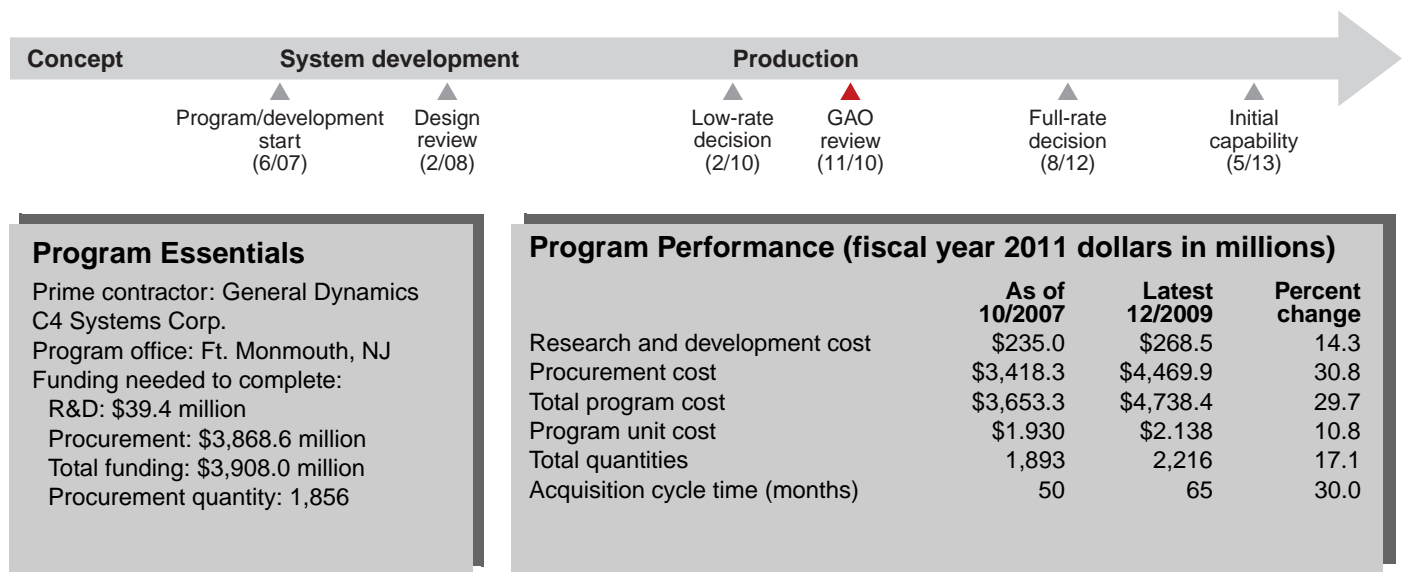
In commenting on a draft of this assessment, the program office provided technical comments, which were incorporated as appropriate.

## Warfighter Information Network-Tactical (WIN-T) Increment 2

WIN-T is the Army's high-speed and high-capacity backbone communications network. WIN-T connects Army units with higher levels of command and provides the Army's tactical portion of the Global Information Grid. WIN-T was restructured following a March 2007 Nunn-McCurdy unit cost breach of the critical threshold, and will be fielded in four increments. The second increment will provide the Army with an initial networking on-the-move capability.



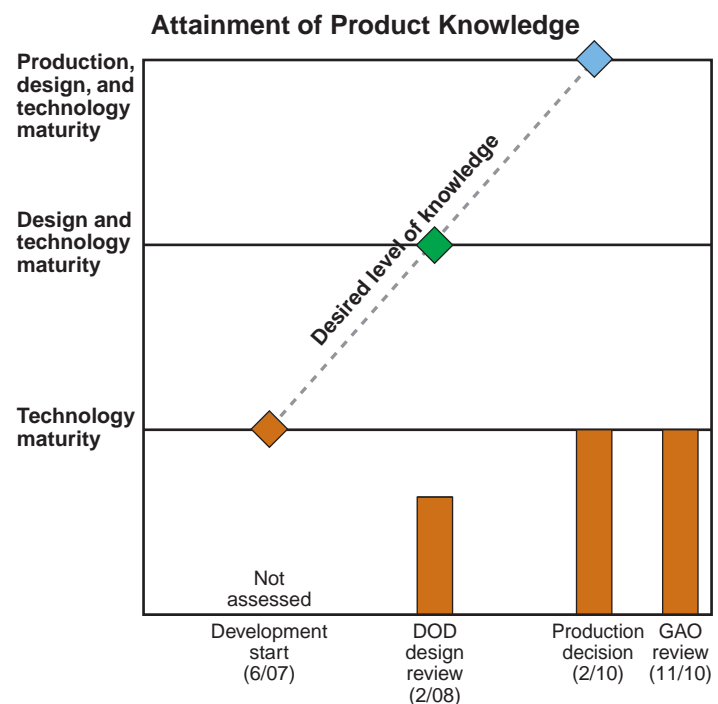
Source: U.S. Army.



### Program Essentials

Prime contractor: General Dynamics C4 Systems Corp.  
 Program office: Ft. Monmouth, NJ  
 Funding needed to complete:  
 R&D: \$39.4 million  
 Procurement: \$3,868.6 million  
 Total funding: \$3,908.0 million  
 Procurement quantity: 1,856

WIN-T Increment 2 entered production in February 2010 with all 15 of its critical technologies mature. However, the program is currently addressing significant performance and reliability shortfalls that were revealed in a March 2009 limited user test. The test results showed that WIN-T Increment 2 did not meet its operational reliability requirements. DOD's Director, Operational Test and Evaluation, recommended that the Army improve performance and training to address these deficiencies and ensure success during initial operational test, which is scheduled for early fiscal year 2012. We could not assess production maturity. According to the Army, WIN-T is primarily an information technology integration effort that relies on commercially available products. Performance is measured through a series of test events to demonstrate performance at increasing levels of system integration.



## **WIN-T Increment 2 Program**

### **Technology Maturity**

All 15 WIN-T Increment 2 critical technologies were mature by its February 2010 production decision. In September 2009, the Army completed a technology readiness assessment to support a low-rate initial production decision. An independent review team reviewed this technology readiness assessment and the body of evidence used to support it and concluded that all 15 critical technologies were mature. In November 2009, the Director, Defense Research and Engineering, concurred with the independent review team's assessment, noting that tests conducted by the Army show that each of WIN-T Increment 2's critical technologies have been demonstrated in a realistic environment.

### **Design Maturity**

We could not assess the design maturity of WIN-T Increment 2 because the program office does not track the number of releasable drawings. According to the program office, WIN-T is primarily an information technology integration effort that relies on commercially available products. Performance is measured through a series of component, subsystem, configuration item, and network level test events designed to demonstrate performance at increasing levels of system integration. Design stability is measured through a problem tracking report system. Problem tracking report trends are reported and tracked on a weekly basis by the program office.

### **Production Maturity**

We could not assess the production maturity of the WIN-T Increment 2. According to the program office, WIN-T is primarily an information technology integration effort that relies on commercially available products.

### **Other Program Issues**

During a March 2009 limited user test, WIN-T Increment 2 failed to demonstrate the ability to support mobile operations as well as the required capabilities in forested terrain. WIN-T Increment 2 operational effectiveness was degraded because the program's concept of operations, organizational structure, and manning were not adequate to operate and troubleshoot the network. Further, the test concluded that the WIN-T Increment 2 did not meet its operational reliability requirements because

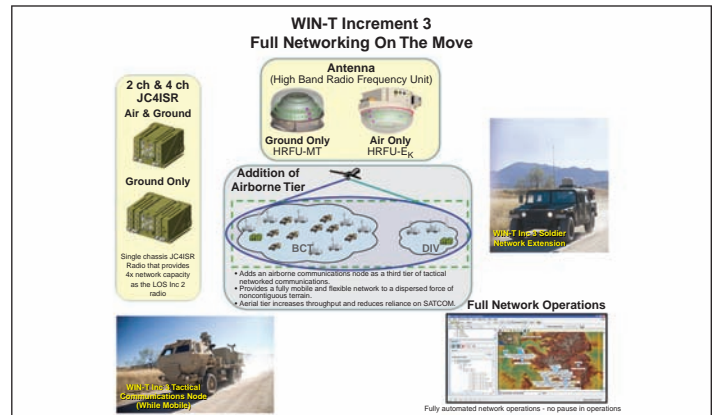
three critical components demonstrated poor reliability. In a January 2010 operational assessment of this limited user test, DOD's Director, Operational Test and Evaluation (DOT&E), recommended that the Army take certain actions to address these deficiencies to ensure success at the WIN-T Increment 2 initial operational test scheduled for the first quarter of fiscal year 2012. DOT&E recommended that the Army improve the performance of the Increment 2 waveforms, provide greater training to soldiers, refine its tactics and manning levels for Increment 2, and aggressively pursue a reliability growth program for WIN-T Increment 2 components. According to the program office, it is working to address these concerns and respond to these recommendations before the start of the program's operational test.

### **Program Office Comments**

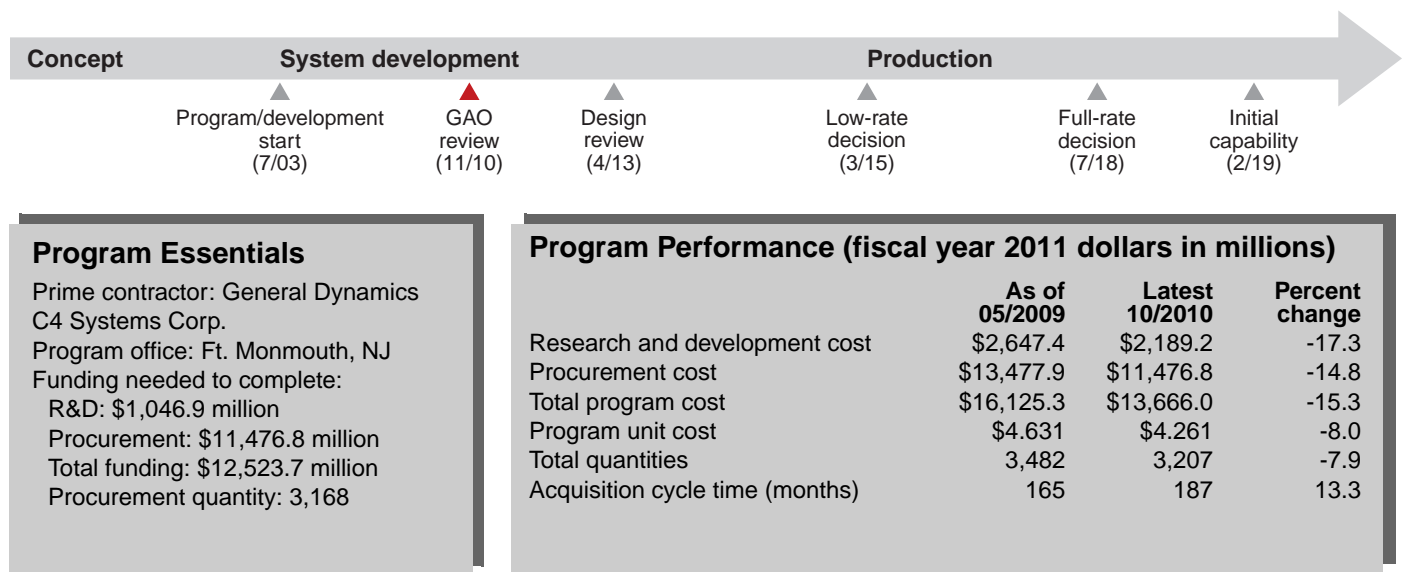
In commenting on a draft of this assessment, the Army addressed (1) the development of a failure mode closure plan, (2) risk reduction events, and (3) production qualification testing for WIN-T Increment 2. With regard to the failure mode closure plan, the Army noted that, as directed by the Office of the Secretary of Defense (OSD), the program office has identified, provided corrections for, tested, and resolved all 37 of WIN-T Increment 2's identified failure modes identified from the limited user test. The Army also noted that a series of OSD-witnessed closure events and formal reports have been completed. With regard to risk reduction, the Army explained that, as directed by OSD, the program office designed, executed, and performed analysis illustrating successful support for seven critical technical performance parameters, including mobile throughput and scalability. With regard to production qualification testing, the Army noted that the program office has two production qualification test events scheduled in fiscal year 2012 to further validate system readiness prior to the initial operational test. The Army also provided technical comments, which were incorporated as appropriate.

## Warfighter Information Network-Tactical (WIN-T) Increment 3

WIN-T is the Army's high-speed and high-capacity backbone communications network. WIN-T connects Army units with higher levels of command and provides the Army's tactical portion of the Global Information Grid. WIN-T was restructured following a March 2007 Nunn-McCurdy unit cost breach of the critical threshold, and will be fielded in four increments. The third increment will provide the Army a full networking on-the-move capability.



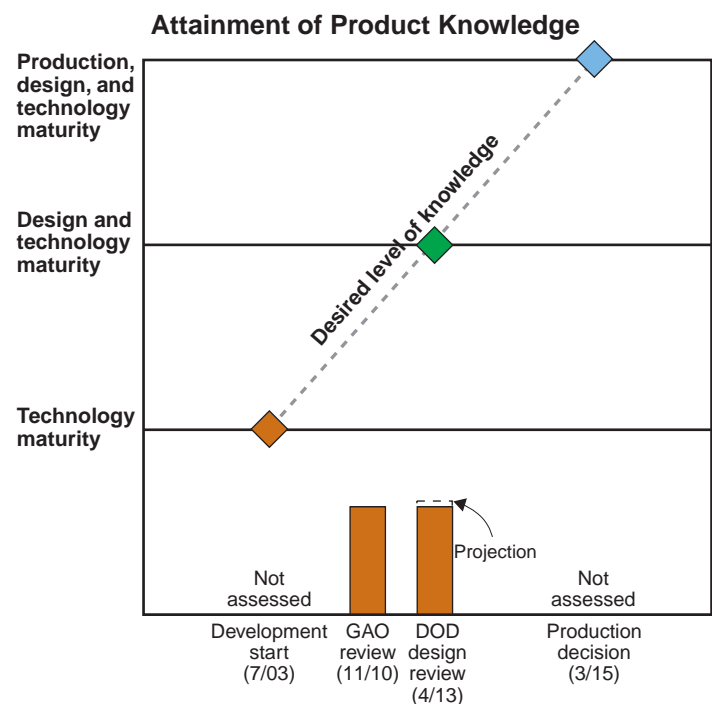
Source: U.S. Army.



### Program Essentials

Prime contractor: General Dynamics C4 Systems Corp.  
 Program office: Ft. Monmouth, NJ  
 Funding needed to complete:  
 R&D: \$1,046.9 million  
 Procurement: \$11,476.8 million  
 Total funding: \$12,523.7 million  
 Procurement quantity: 3,168

The WIN-T Increment 3 program will not fully mature its critical technologies until its planned March 2015 production decision. Three of the program's 20 critical technologies are currently mature and 15 are nearing maturity. Of the two remaining technologies, one was rated as nearing maturity by an independent review team; but, the Director, Defense Research and Engineering, concluded that the technology's ambiguous requirements made it difficult to state whether it had been adequately demonstrated. The other technology—a cryptographic device whose development is being managed by the National Security Agency—has not been formally rated. The Army recently developed a revised WIN-T Increment 3 acquisition program baseline to account for changes due to the cancellation of the Future Combat System program.





## WIN-T Increment 3 Program

### Technology Maturity

The WIN-T Increment 3 program will not fully mature its critical technologies until its planned March 2015 production decision. An April 2009 review of the Army's technology readiness assessment for WIN-T Increment 3 by the Director, Defense Research and Engineering (DDR&E), concluded that, of the program's 20 critical technologies, 3 were mature and 15 were nearing maturity.

Of the two remaining technologies, the Quality of Service Edge Device (QED) was rated as nearing maturity in the Army's assessment; however, DDR&E concluded that this technology had ambiguous requirements that made it difficult to state whether it had been adequately demonstrated. DDR&E noted that while the Army had demonstrated that the QED technology met requirements under most conditions, in one stressing scenario, it did not. DDR&E representatives believe that it is unlikely that any network can meet this requirement in all environments. Since the QED technology was shown to be robust and capable of meeting its requirement in most scenarios, DDR&E recommended that the Army clarify the user's requirements for this technology by the next design review. According to a program office official, the Army's Training and Doctrine Command has revisited user requirements for this critical technology; however, a new rating for this technology will not be formalized until the program's design review, currently scheduled for February 2014.

The other remaining technology—High Assurance Internet Protocol Encryptor (HAIZE) version 3.X—was not available to be rated at the time of DDR&E's review in April 2009. HAIZE is a device that encrypts and encapsulates Internet protocol packets so that they can be securely transported over a network of a different security classification. Version 1.3.5 of HAIZE is mature; however, according to the WIN-T program office, its use in WIN-T Increment 3 would result in a less efficient network design. DDR&E has notified the Army that the maturity of the HAIZE version 3.X technology should be established to DDR&E's satisfaction before it is transitioned into WIN-T Increment 3. The National Security Agency

(NSA) manages the HAIZE program, and is responsible for certifying that vendors' HAIZE products comply with the HAIZE interoperability specification. According to an NSA representative, NSA has informally assessed HAIZE 3.X and believes it is mature. However, NSA has not been tasked by the Army or DDR&E with providing a formal assessment of HAIZE 3.X's technology maturity. As a result, our assessment and presentation of WIN-T's Increment 3's technology maturity excludes this critical technology.

### Design Maturity

We could not assess the design stability of the WIN-T Increment 3 because the program office does not track the number of releasable drawings. According to the program office, this metric is not meaningful because WIN-T is not a manufacturing effort, but rather an integration effort. Performance is measured through a series of component, subsystem, configuration item, and network level test events designed to demonstrate performance at increasing levels of system integration. Design stability is measured through a problem tracking report system. Problem track report trends are reported and tracked on a weekly basis by the program office.

### Other Program Issues

In May 2009, the Under Secretary of Defense for Acquisition, Technology and Logistics approved a revised acquisition program baseline for the WIN-T Increment 3 program. However, this new baseline was developed prior to the Secretary of Defense's recommended cancellation of the Future Combat System (FCS) program, which was closely related to WIN-T Increment 3. As a result, the Under Secretary restricted the Army from obligating or expending WIN-T Increment 3 funds associated directly with FCS and directed that a new cost estimate and acquisition program baseline be completed and approved. In October 2010, the Under Secretary approved a revised acquisition program baseline for WIN-T Increment 3, based on an independent cost estimate prepared by the Director, Cost Assessment and Program Evaluation (CAPE), that reflects the restructured program.

### Program Office Comments

In commenting on a draft of this assessment, the Army provided technical comments, which were incorporated as appropriate.



## Air and Missile Defense Radar (AMDR)

The Navy's Air and Missile Defense Radar (AMDR) will be a next-generation radar system designed to provide ballistic missile defense, air defense, and surface warfare capabilities. AMDR will consist of an S-band radar for ballistic missile defense and air defense, X-band radar for horizon search, and a radar suite controller that controls and integrates the two radars. AMDR will initially support DDG 51 Flight III. The Navy expects AMDR to provide the foundation for a scalable radar architecture to defeat advanced threats.



Source: U.S. Navy.

### Current Status

The AMDR program entered technology development in September 2010 and is one of the first programs to incorporate affordability cost targets as part of the acquisition strategy. In addition, in September 2010, the Navy awarded three fixed-price incentive fee contracts to Northrop Grumman, Lockheed Martin, and Raytheon for S-band radar and radar suite controller technology development. The contractors will build and test prototypes to demonstrate the critical technologies during a 2-year technology development period. The Navy then plans to conduct a limited competition among the technology development contractors for engineering and manufacturing development. According to the program's technology development strategy, the X-band radar technology is mature and the Navy plans to acquire it through full and open competition. The Navy will provide it as government-furnished equipment to the S-band and radar suite controller contractor to manage the integration during engineering and manufacturing development. Additional software development will be required to integrate the two radars.

To support the decision to enter technology development, the Navy conducted an early evaluation of technology maturity and identified six candidate critical technologies—four hardware-related and two software-related. According to program officials, digital beamforming—necessary for AMDR's simultaneous air defense and ballistic missile defense mission—will likely take the longest time in development to mature. Program officials stated that while this technology is currently in use on existing radars, it has not been demonstrated on a large-aperture radar. The Navy is coordinating with the Air Force's Space Fence program on the S-band radar's technology development. The Navy estimates that AMDR will be available for delivery to a shipyard in fiscal year 2019.

**Estimated Total Program Cost:** \$15,668.8 million

Research and development: \$2,257.6 million

Procurement: \$13,382.9 million

Quantities: 24

**Next Major Program Event:** Preliminary design review, July 2012

**Program Office Comments:** The AMDR program office concurred with this assessment and provided technical comments, which were incorporated as appropriate.

## B-2 Defensive Management System (DMS) Modernization

The Air Force's B-2 DMS modernization is expected to upgrade the 1980s-era analog defensive management system to a digital capability. The modernization effort is intended to improve the frequency coverage and sensitivity of the electronic warfare suite, as well as update pilot displays and inflight replanning capability for avoiding unanticipated air defense threats. It is also expected to improve reliability and maintainability for the system. According to program officials, the current DMS is a major readiness driver for the aircraft.



Source: U.S. Air Force.

### Current Status

In June 2010, the B-2 DMS program received its material development decision and entered the material solution analysis phase. As part of this phase, the program will conduct an analysis of alternatives. According to program officials, the analysis of alternatives will consider three options: (1) a minimum upgrade (only critical electronic parts of current DMS); (2) a fully modernized DMS; and (3) an incremental DMS upgrade. Upon completion of the analysis of alternatives, the program anticipates entering the technology development phase in March 2011. The program tentatively plans to enter engineering and manufacturing development in 2013 after it completes its preliminary design review, and projects an initial operational capability for the B-2 DMS around fiscal year 2020.

A primary focus for the B-2 DMS program in technology development will be the low-observable antennas for the B-2's leading edges. Overall, the program office has identified six critical technologies. According to the program office, five of the critical technologies are nearing maturity or are mature and have been demonstrated in a relevant or realistic environment. The low-observable antennas for the B-2 leading edges are the least mature. The primary risk with the technology's development will be achieving the desired performance while still meeting the low-observable requirements of the aircraft. During the technology development phase, the program does not plan to develop prototypes of the full B-2 DMS, but instead plans to develop prototype antenna subsystems, which is the area it believes contains the most technological risk.

**Estimated Total Program Cost:** \$1,505.8 million

Research and development: \$937.1 million

Procurement: \$568.7 million

Quantities: 20

Note: This is an initial draft cost estimate developed by the program office. A formal baseline cost estimate is expected for the milestone A decision scheduled for March 2011.

**Next Major Program Event:** Technology development start (milestone A), March 2011

**Program Office Comments:** The program was provided a draft of this assessment and had no comments.

## B-2 Extremely High Frequency (EHF) SATCOM Capability, Increment 2

The Air Force's B-2 EHF SATCOM is a satellite communication system designed to upgrade the aircraft's ultra high frequency system to ensure continued secure, survivable communication. The system has three increments, with each expected to be its own program. Increment 2 is designed to provide connectivity by adding low-observable antennas and radomes to the aircraft. It also includes separate, nonintegrated Family of Advanced Beyond Line-of-Sight Terminals (FAB-T) and related hardware.



Source: U.S. Air Force.

### Current Status

The B-2 EHF Increment 2 program is in technology development. In March 2008, the program began a component advanced development effort that includes systems engineering, requirements analysis, technology maturation, and preliminary design activities. The program plans to enter engineering and manufacturing development in fiscal year 2013—3 years later than originally planned.

The B-2 EHF Increment 2 program has attempted to make decisions that balance requirements with technical solutions; however, antenna technology maturation and FAB-T availability still pose risks. For example, as a result of a recent trade study, the program's key performance parameters were revised to reflect what is achievable and technically feasible. In addition, the Air Force changed the antenna location and technology to an active electronically scanned array (AESA) to lower risk. These decisions are expected to mitigate integration risks, but technology maturation risks still exist. The program expects its critical technologies to be nearing maturity by development start, but current technology readiness levels for AESA are relatively low and the program does not have a fallback antenna technology option should the AESA technology not mature as expected. An Air Force review also raised concerns that the decision to pursue AESA technologies exclusively may have precluded the use of lower risk, more affordable and mature technologies. In addition to these challenges, the availability of FAB-T hardware, which enables voice and data satellite communication, has significantly delayed the program. Due in part to the FAB-T delays, the B-2 EHF Increment 2 will not begin production by the current U.S. Strategic Command need date in fiscal year 2016. The program's initial operational capability is expected in March 2020.

**Estimated Total Program Cost:** \$1,796.7 million

Research and development: \$1,331.2 million

Procurement: \$464.5 million

Quantities: 20

**Next Major Program Event:** Engineering and manufacturing development start, March 2013

**Program Office Comments:** In commenting on a draft of this assessment, the program office noted that a 2008 trade study validated program risk areas related to the antenna's technology and planned location on the B-2. This study concluded that changing the antenna's technology to an electrical antenna would considerably reduce risk, allowing relocation and, as a result, precluded negative effects on the B-2's structure and radar cross section. The Air Force also provided technical comments, which were incorporated as appropriate.

## BMDS: Airborne Laser Test Bed (ALTB)

MDA's ALTB, formerly the Airborne Laser program, is being developed as an advanced platform for the Department of Defense's directed energy research program. The ALTB platform includes two solid state lasers and a high-energy laser housed aboard a modified Boeing 747-aircraft. The ALTB will transition to a national test platform over the next 4 years.



Source: Missile Defense Agency.

### Current Status

Until recently, MDA's Airborne Laser program was developing a prototype system to negate enemy missiles during the boost phase of flight. However, after spending more than \$5 billion on its development, DOD designated it as a test bed to demonstrate the potential of using directed energy as a viable technology against ballistic missiles. In February 2010, MDA demonstrated that the ALTB could successfully destroy a short-range threat-representative ballistic missile during the boost phase. According to the Director of Operational Test and Evaluation (DOT&E), the demonstration utilized a realistic target and was the most operationally relevant test of the Airborne Laser to-date. However, DOT&E also noted that despite the realism of the target missile, the test was not operationally realistic because a key component of the ALTB's detection and tracking system was removed because it exhibited technical issues during earlier ground and flight testing. MDA conducted its second major flight test of the ALTB in early September 2010 against a short-range ballistic missile in the boost phase, but failed to destroy the target. The ALTB successfully detected and tracked the target, but corrupted beam control software steered the high-energy laser slightly off center. The ALTB safety system detected this shift and shut down the high-energy laser. MDA conducted a third flight test in October 2010 against a solid-fuel missile. However, while the system seems to have successfully acquired and tracked the plume or rocket exhaust of the target, it never transitioned to active tracking. As a result, the laser was not fired. The laser incorrectly reported that it was not ready and the safety default aborted the engagement.

**Total Program Funding:** NA

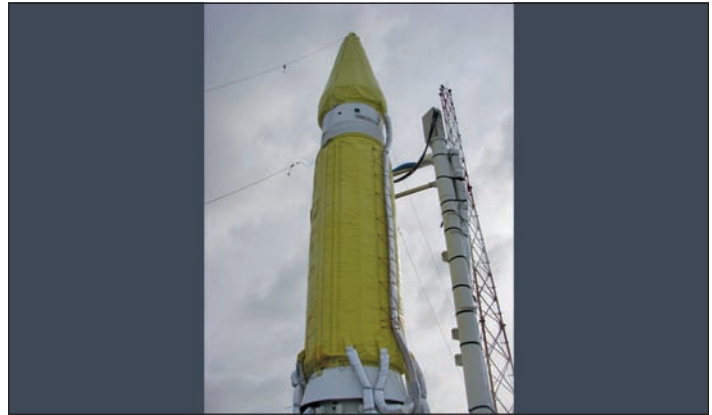
**Next Major Program Event:** NA

**Program Office Comments:** In commenting on a draft of this assessment, the ALTB program acknowledged DOT&E's comments but noted that the test bed is focused on scientific learning rather than proof of operational capability. According to the program, MDA is collaborating with the Office of the Secretary of Defense to establish experiments that maximize benefits for DOD directed-energy programs. In fiscal year 2010, the ALTB conducted 40 flight experiments, including engagements of eight boosted targets. The ALTB also destroyed a solid-fuel metal-body target missile prior to its first major flight test. In May 2010, ALTB successfully engaged a diagnostic target missile at twice the range of the February experiments—a key risk-reduction event for future experiments. MDA continues to support directed energy as a hedge against the ever-changing threat environment.



## BMDS: Flexible Target Family (FTF)

MDA's Flexible Target Family was designed to be a family of short-, medium-, and long-range targets with common components for ground-, air-, and sea-launch capabilities. MDA is currently producing a groundlaunched, intermediate-range target, the LV-2, for BMDS flight tests. It is also developing a second target in this family, the 52-inch extended medium range ballistic missile target (eMRBM).



Source: Missile Defense Agency.

### Current Status

The LV-2 has been successfully tested and is in production. MDA flew the first LV-2 target vehicle in January 2010. During this test, the program was able to demonstrate all the critical technologies necessary for the LV-2 in the current BMDS test plan. These technologies had not been flight tested in the necessary form, fit, and function before production began. There are currently five additional LV-2 target missiles in various stages of production, all in the same configuration. In order to assess production risks, the contractor is collecting data on labor hours and scrap, rework, and defect rates and has reported that these measures are tracking as expected. MDA had originally planned to produce at least one alternative configuration of the LV-2 that used a shrouded reentry vehicle, but the mission requiring this technology was dropped from the agency's test plan. MDA officials said they could purchase additional LV-2 targets, but no additional ones are currently under contract. The second LV-2 flight test was scheduled for the first quarter of fiscal year 2011.

MDA is not planning to conduct a risk-reduction flight for the second Flexible Target Family vehicle, the 52-inch eMRBM, because of budget constraints. This target uses more than 90 percent of the same ground and flight software, and 72 percent of the same components as the LV-2. However, these components must be incorporated into a new, smaller structure, which could pose an integration risk. MDA plans to use the first two eMRBMs in a BMDS operational test in 2012. In April 2010, MDA began acquiring the first three eMRBMs, and in September 2010 increased the quantity from three to five. MDA expects to complete negotiations and definitize the contract in July 2011.

**Total Funding for LV-2 (Fiscal years 2005 to 2013):** Research and development \$622.2 million  
Quantities: 6

**Next Major Program Event:** Third LV-2 flight test, third quarter fiscal year 2011

**Program Office Comments:** In commenting on a draft of this assessment, MDA provided technical comments, which were incorporated as appropriate.

## C-27J Joint Cargo Aircraft (JCA)

The Air Force's C-27J is a commercially available, multifunctional small-to-medium-size cargo aircraft. It is designed to help meet time-sensitive and mission critical transport requirements, and to augment the Air Force's intratheater lift inventory. Its mission also includes casualty evacuation, airdrop, troop transport, aerial sustainment, and homeland security. The aircraft is capable of carrying up-armored High Mobility Multipurpose Wheeled Vehicles and heavy, dense loads such as aircraft engines and ammunition.



Source: L-3 Communications.

### Current Status

The C-27J Joint Cargo Aircraft program has been in production since June 2007. The sixth aircraft was delivered in November 2010. The program completed the transition from an Army-led joint program to an Air Force program in October 2010. Current plans are to procure 38 aircraft and assign them to Air National Guard bases. The Air Force Air Mobility Command and the National Guard Bureau have identified the first six locations to receive C-27J aircraft as Mansfield, Ohio; Baltimore, Maryland; Meridian, Mississippi; Battle Creek, Michigan; Fargo, North Dakota; and Bradley, Connecticut. The C-27J program office has established a foreign military sales section which has received requests for information about pricing and availability from a number of countries. However, as of July 2010, no foreign military sales cases had been initiated.

The C-27J program was to achieve initial operational capability in August 2010, but due to delays in multi-service operational test and evaluation, as well as delays in receiving certification from the Federal Aviation Administration, initial capability is now anticipated for January 2011. In June 2010 the Air Force received authorization from the Under Secretary of Defense for Acquisition, Technology and Logistics to expand the low-rate initial production procurement (LRIP) by up to 8 aircraft, to a total of 21. This does not affect the total quantities. Program officials explained that the firm fixed-price contract for the C-27J is based on prices established according to the number of aircraft purchased in a given period. By expanding the maximum number of LRIP aircraft, the program was able to order 8 aircraft in the latest ordering period at the currently agreed upon price rather than waiting for the next ordering period. According to program officials, this helped save an estimated \$19 million and avoid a significant break in production.

**Estimated Total Program Cost:** \$1,966.3 million

Research and development: \$118.3 million

Procurement: \$1,773.2 million

Quantities: 38

**Next Major Program Event:** Full-rate production decision, February 2011

**Program Office Comments:** The program office was provided a draft of this assessment and did not offer any comments.

## DDG 51 Destroyer

The Navy's DDG 51 destroyer is a multimission surface ship designed to operate against air, surface, and subsurface threats. The Navy started buying DDG 51 destroyers in 1985 and expects to have 62 destroyers in service by 2012. In 2008, the Navy announced it would continue the program and plans to buy nine more ships over the next 5 years. The Navy then expects to start buying a new version of the ship—Flight III—in fiscal year 2016. Initial plans for Flight III include an increased emphasis on ballistic missile defense.



Source: U.S. Navy.

### Current Status

In 2008, the Navy announced its plan to restart the DDG 51 Flight IIA production line. The Navy anticipates that construction of DDG 113—the first ship in the restart program—will begin in fiscal year 2012 after an approximate 4-year gap in new DDG 51 starts. While program officials do not currently anticipate utilizing any new technologies or changing the Flight IIA design, the Navy could decide to use a hybrid electric drive designed to reduce fuel consumption on both new and existing DDG 51 destroyers, as well as in future designs, if it proves to be successful. The system is currently a prototype. The Navy is also working to address any industrial base issues that result from the production gap. For example, officials stated that before the Navy decided to restart DDG 51 production, the existing contractor for DDG 51 main reduction gears sold its production line. The Navy conducted a full and open competition and will now provide the gears as government-furnished equipment.

According to the program officials, a new air and missile defense radar will be the major technology effort for Flight III. The radar is being developed through a separate program office. According to the DDG 51 program, improving power generation on Flight III will be important to accommodate the expected increase in power and cooling requirements for this radar. The radar could also pose a risk for Flight III construction. The Navy estimates that it will not be available for delivery to a shipyard until fiscal year 2019—2 years prior to ship delivery according to the Navy. Officials stated that a decision has not been made to determine where the DDG 51 program will start in DOD's milestone review process for the development and acquisition of the Flight III changes.

**Estimated Total Program Cost (fiscal years 2010-2015):** \$16,926.5 million

Research and development: \$140.8 million

Procurement: \$16,785.7 million

Quantities: 9

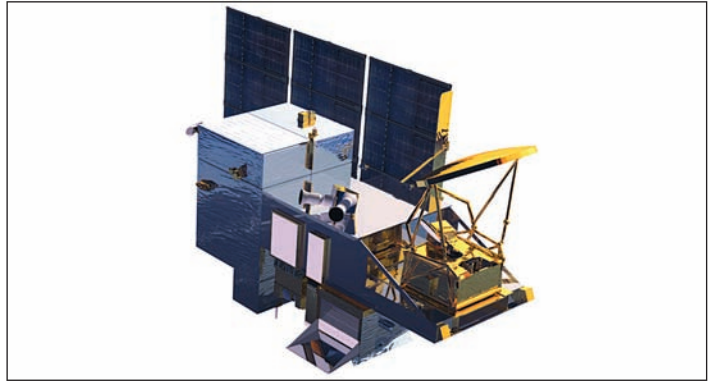
**Next Major Program Event:** DDG 113 construction start, fiscal year 2012

**Program Office Comments:** The program office provided technical comments, which were incorporated as appropriate.



## Defense Weather Satellite System (DWSS)

DOD's Defense Weather Satellite System (DWSS) is a next-generation polar-orbiting environmental satellite system with primary coverage in the early morning orbit. The system will incorporate data from the National Oceanic and Atmospheric Administration (NOAA) / National Aeronautics and Space Administration (NASA) Joint Polar Satellite System (JPSS) in the afternoon and from the European Meteorological Operational (MetOp) satellite in mid-morning.



Source: Northrop Grumman.

### Current Status

In February 2010, the Executive Office of the President announced that the National Polar-orbiting Operational Environmental Satellite System (NPOESS) program was being restructured because of long-standing cost, schedule, and performance issues and management deficiencies. DOD and NOAA/NASA were directed to proceed with separately-managed acquisitions—DWSS for DOD and JPSS for NOAA/NASA. Currently, DOD obtains weather data through Defense Meteorological Satellite Program (DMSP) satellites. The Air Force launched a DMSP satellite in 2009 and has two remaining satellites, which it plans to launch as needed. To ensure continued coverage, the Air Force plans to have DWSS satellites available for launch in 2018 and 2021.

To reduce developmental risks and lower acquisition costs, the Air Force expects to leverage to the maximum extent the technology and investments made in the NPOESS program. The DWSS satellite bus is a modified NPOESS bus, but reduced in size and weight to meet DOD mission requirements. DWSS plans to use the visible infrared imager radiometer suite (VIIRS) sensor planned for NPOESS, as well as the ground control system based on the NPOESS design. The Air Force is evaluating microwave sensor alternatives, focusing on affordability while still providing DMSP-comparable microwave capability.

### Estimated Total Program Cost: TBD

Research and development: TBD

Procurement: NA

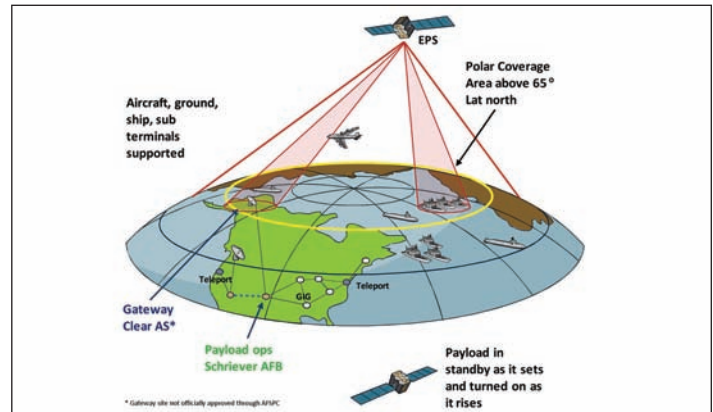
Quantities: 2

**Next Major Program Event:** Materiel development decision, February 2011

**Program Office Comments:** Program officials stated they are working on restructuring the NPOESS prime contract to facilitate transition of civil NOAA/NASA work while focusing on DOD mission needs. Also, DOD and NOAA/NASA are working to complete a memorandum of agreement on sharing common elements at the VIIRS contractor and DOD plans to acquire duplicate test sets and ground support equipment to minimize single supplier issues.

## Enhanced Polar System (EPS)

The Air Force's Enhanced Polar System (EPS) will provide next-generation protected extremely high frequency (EHF) satellite communications in the polar region above 65 degrees northern latitude. EPS will replace the current Interim Polar System and serve as a polar adjunct to the Advanced EHF (AEHF) system. EPS consists of two EHF payloads hosted on classified satellites. A gateway will connect modified AEHF communications terminals to other communication systems utilizing an extension of the AEHF mission control segment.



Source: LinQuest Corporation.

### Current Status

The EPS program is preparing to enter system development. It was initiated in fiscal year 2006 to fill the gap left by the cancellation of the Advanced Polar System. In December 2007, the Under Secretary of Defense for Acquisition, Technology and Logistics directed the program to bypass concept development and proceed to a system development decision in order to synchronize the program's schedule with the host satellite production timeline. Since then, the Air Force has determined that the EPS program would require additional payload engineering and changes to the gateway, and the program's entry into system development has been delayed from February 2010 to the third quarter of fiscal year 2011. In addition, the program's projected cost could significantly increase. According to program officials, the EPS program did not have an opportunity to develop a complete and thorough cost estimate because it was directed to proceed directly to a system development decision. The fiscal year 2011 President's budget request included about \$1 billion for the program through fiscal year 2015; however, program officials stated that the new cost estimate might require double this amount. Before the EPS program can enter system development, the milestone decision authority will have to certify that this funding is available.

According to the program office, EPS critical technologies are mature. Although the program does not plan to conduct prototyping prior to the start of development, program officials noted the EPS has conducted prototyping in the payload, ground, gateway, and terminal segments as part of the technology development phase of the program. According to DOD acquisition policy, the technology development strategy for each major defense acquisition program shall provide for prototypes of the system or, if a system prototype is not feasible, for prototypes of critical subsystems before it gets approval to enter the engineering and manufacturing development phase.

**Estimated Total Program Cost:** \$1,490.7 million

Research and development: \$1,395.4 million

Procurement: \$79.7 million

Quantities: 2

**Next Major Program Event:** System development decision, third quarter of fiscal year 2011

**Program Office Comments:** The EPS program office provided technical comments, which were incorporated as appropriate.

## F-22A Raptor

The Air Force's F-22A Raptor is the only fifth-generation operational air-to-air and air-to-ground fighter/attack aircraft. This aircraft integrates stealth, supercruise, and advanced avionics, maneuverability, and weapons in one platform. The Air Force established the F-22A modernization and improvement program in 2003 to add enhanced air-to-ground, information warfare, reconnaissance, and other capabilities and improve the reliability and maintainability of the aircraft.



Source: U.S. Air Force.

### Current Status

In April 2009, the Secretary of Defense announced that F-22A production would end at 187 aircraft, and as of September 2010, the Air Force had accepted delivery of 160 aircraft. According to the Director, Operational Test and Evaluation, the F-22A could have difficulty meeting operational suitability requirements relating to low-observable maintainability when the system reaches full maturity. Air Force officials reported that the low-observable materials are difficult to manage and maintain, requiring nearly twice the number of maintenance personnel as anticipated.

The Air Force is upgrading the F-22A fleet in four increments. The first increment has been fielded. The second increment—Increment 3.1—will begin follow-on operational test and evaluation in January 2011. These increments add enhanced air-to-air and air-to-ground; intelligence, surveillance, and reconnaissance; and synthetic aperture radar capabilities. The third increment—Increment 3.2—has been divided into two phases. The first will deliver electronic protection, combat identification, and Link 16 communication upgrades beginning in 2014. The second phase will begin fielding AIM-9X and AIM-120D capabilities, and additional electronic protection upgrades beginning in 2016. The multifunction advanced datalink, planned to provide interoperability with the F-35 Joint Strike Fighter, was removed from Increment 3.2 after costs increased significantly over initial estimates and the program was unable to secure fiscal year 2010 funding. Increment 3.3 will enable compliance with air traffic management standards, but the additional content for this increment has not yet been determined.

**Estimated Total Program Cost:** \$77,392.8 million

Research and development: \$39,171.7 million

Procurement: \$37,560.5 million

Quantities: 188

**Next Major Program Event:** Final aircraft delivery, February 2012

**Program Office Comments:** The Air Force acknowledged challenges associated with maintaining a fifth-generation low-observable system, and said there are currently more than 10 ongoing efforts under the reliability and maintainability maturation program to increase maintainability and material durability. The Air Force also stated that the majority of repairs to the low observable system resulted from having to perform other maintenance activities, rather than to address problems with the low observable system itself. According to the service, all operational units have reported mission capable rates for the low-observable system of about 90 percent, since January 2009. The Air Force also provided technical comments, which were incorporated as appropriate.

## H-1 Upgrades (UH-1Y/AH-1Z)

The Navy's H-1 Upgrades Program converts the AH-1W attack helicopter and the UH-1N utility helicopter to the AH-1Z and UH-1Y configurations, respectively. The mission of the AH-1Z attack helicopter is to provide rotary-wing fire support and reconnaissance capabilities in day/night and adverse weather conditions. The mission of the UH-1Y utility helicopter is to provide command, control, and assault support under the same conditions.



Source: U.S. Navy.

### Current Status

The UH-1Y and AH-1Z configurations are in production. DOD approved full-rate production for the UH-1Y in September 2008. The program received approval to enter full-rate production for the AH-1Z in November 2010. The Navy completed operational testing and evaluation for the AH-1Z in June 2010. The evaluation report, issued in September 2010, concluded that the AH-1Z is operationally effective and suitable, and recommended the aircraft for introduction in the fleet. The report also highlighted concerns with logistics supportability and recommended this deficiency be corrected prior to the first AH-1Z operational deployment.

In July 2010, the Deputy Commandant of the Marine Corps for Aviation issued a directive changing the composition of H-1 program procurements from 123 UH-1Ys and 226 AH-1Zs to 160 UH-1Ys and 189 AH-1Zs. The Deputy Commandant cited increased demand for utility helicopters in support of combat operations and the increase in combat power of the AH-1Z compared to the AH-1W as support for the directive. As of November 2010, there were 98 H-1 upgrades under contract, and 46 aircraft—34 UH-1Ys and 12 AH-1Zs—had been delivered to the fleet.

**Estimated Total Program Cost:** \$11,866.5 million

Research and development: \$1,855.3 million

Procurement: \$10,011.2 million

Quantities: 4 (Research and Development), 349 (Procurement)

**Next Major Program Event:** Initial operational capability, AH-1Z, second quarter fiscal year 2011

**Program Office Comments:** The Navy provided technical comments, which were incorporated as appropriate.



## Joint Light Tactical Vehicle (JLTV)

The Army and Marine Corps' Joint Light Tactical Vehicle is a family of vehicles focused on balancing personnel protection, payload, and performance. JLTV is expected to reduce life-cycle costs through commonality at the subassembly and component level. The JLTV is expected to provide defensive measures for troops while in transport, increase payload capability, improve the logistics footprint, and reduce soldier workload associated with system operation and field maintenance activities.



Source: Department of Defense.

### Current Status

In December 2007, the Under Secretary of Defense for Acquisition, Technology and Logistics directed the Army to begin a 27-month technology development phase for the JLTV program with the goal of reducing risks prior to and shortening the length of system development. Prior to entering engineering and manufacturing development, the JLTV program will develop prototypes, demonstrate critical technologies in a relevant environment, and conduct a preliminary design review, as required by DOD policy. In October 2008, the Army awarded three technology development contracts. The three contractors delivered prototype vehicles in May 2010. Testing on the prototypes has begun and is expected to last about a year. At the conclusion of technology development, the Army plans to hold a full and open competition and award two engineering and manufacturing development contracts. One of these two contractors will be selected for production.

The JLTV's acquisition costs have not been determined, but based on evolving user requirements the JLTV average unit manufacturing cost is estimated at \$356,000. This cost does not include contractor general and administrative cost, contractor profit, or government-furnished equipment. The program has a demanding set of projected requirements and tradeoffs may be necessary. Among the program's key challenges is whether the vehicle can provide the performance and reliability required within the weight limits for helicopter transport.

**Estimated Total Program Cost:** \$53,523.3 million

Research and development: \$1,082.2 million

Procurement: \$52,298.3

Quantities: 60,383

**Next Major Program Event:** Engineering and manufacturing development start, January 2012

**Program Office Comments:** In commenting on a draft of this assessment, the program office stated that JLTV provides a design that supports mobility, reliability, and maintainability within weight limits to ensure transportability to and from the battlefield. The program office also noted that JLTV uses scalable armor solutions to meet requirements for added protection while maintaining load carrying capacity.

## KC-X Program

The Air Force's KC-X program is the first of three phases in the recapitalization of the KC-135 aerial refueling tanker fleet. The KC-X acquisition strategy calls for the procurement of 179 commercial derivative aircraft tankers at an expected cost of around \$35 billion. The KC-X is planned to provide sustained aerial refueling capability to facilitate global attack, air-bridge, deployment, sustainment, employment, redeployment, homeland defense, theater support, and specialized national defense missions.



Source: U.S. Air Force.

Note: Photo is of the KC-135 Stratotanker, the aircraft the KC-X will replace.

### Current Status

The KC-135 recapitalization effort is the Air Force's highest acquisition priority. It is expected to involve the procurement of about 600 aircraft over a 40-year period with a cost that could exceed \$100 billion. The first phase of this recapitalization—the KC-X program—is in source selection. According to the Office of the Secretary of Defense, the Air Force plans to award a fixed-price incentive fee contract for the engineering and manufacturing development phase of the KC-X program in early fiscal year 2011. The request for proposal for this contract requires all critical technologies to be at a technology readiness level 6—demonstrated in a relevant environment—or higher. According to its current acquisition strategy, the primary technical risk for the KC-X program is the integration of military hardware and software on a commercial platform. The Air Force plans to begin procurement of four aircraft for development and testing purposes in fiscal year 2011.

The Air Force has experienced numerous delays in awarding a development contract. In February 2008, the Air Force awarded a development contract to Northrop Grumman and the European Aeronautic Defense and Space Company. However, the contract award was the subject of a bid protest that was sustained by GAO. As a result, in October 2008, the Office of the Secretary of Defense directed the Air Force to terminate the contract and conduct a new competition.

### Estimated Total Program Cost: TBD

Research and development: TBD

Procurement: TBD

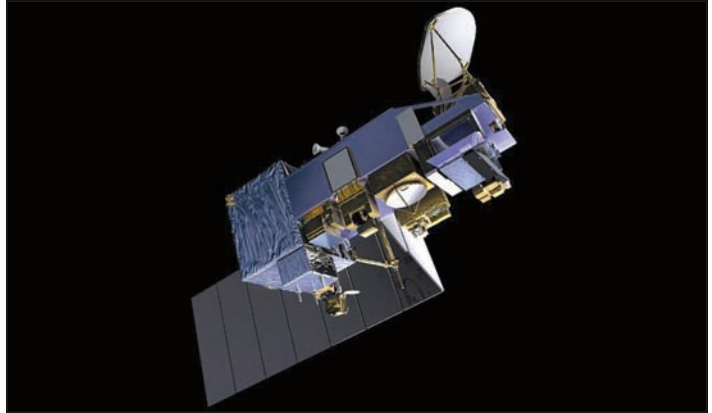
Quantities: 179

**Next Major Program Event:** Engineering and manufacturing development start, early fiscal year 2011

**Program Office Comments:** The Office of the Director of Defense Procurement and Acquisition Policy provided technical comments on a draft of this assessment, which were incorporated as appropriate.

## National Polar-orbiting Operational Environmental Satellite System (NPOESS)

Until it was significantly restructured in February 2010, NPOESS was a triagency program with the Department of Commerce (National Oceanic and Atmospheric Administration), DOD (Air Force), and the National Aeronautics and Space Administration (NASA) designed to merge civil and defense weather satellite programs to reduce costs, provide global weather and climate coverage, and improve capabilities above current fielded systems.



Source: Northrop Grumman.

### Current Status

In February 2010, the Executive Office of the President announced that the NPOESS program was being restructured because of long-standing cost, schedule, and performance issues and management deficiencies. As part of the restructuring, DOD, NOAA, and NASA were directed to proceed with separately-managed acquisitions—the Defense Weather Satellite System (DWSS) and the civilian Joint Polar Satellite System (JPSS). DOD, NOAA, and NASA will still be responsible for meeting NPOESS weather and climate observational requirements in their assigned orbits. DOD will be responsible for collecting weather and climate data during the early morning orbit. NOAA and NASA will be responsible for collecting weather and climate data during the afternoon orbit. These agencies are expected to share data from a common ground system to be managed by NOAA and NASA.

According to the Executive Office of the President, the JPSS will consist of platforms based on the NPOESS Preparatory Project (NPP) satellite. NOAA is currently developing its plan for the JPSS and is considering options such as developing a smaller satellite than the one planned for NPOESS and removing sensors that were planned for the NPOESS satellites. NOAA will have to manage a series of challenges during the transition from NPOESS to JPSS, including the resolution of existing contracts and intellectual property issues and the loss of skilled workers. NOAA also has to address risks related to the readiness of ground systems to support the planned October 2011 NPP satellite launch and the instrument readiness to support a JPSS launch in 2014.

DOD is in the early stages of planning its approach for the DWSS program. See page 138 for more information about the status of the program.

**Estimated Total Program Cost:** According to program officials, the estimated total program cost for NPOESS was about \$5.3 billion when last reported in fiscal year 2010.

**Next Major Program Event:** NA

**Program Office Comments:** We did not request comments on this assessment because the NPOESS program office was disbanded before we completed our review.



## Navy Unmanned Combat Air System Aircraft Carrier Demonstration (UCAS-D)

The Navy's UCAS-D program plans to demonstrate and mature technologies that could be used on a future unmanned, long-range, low-observable carrier-based aircraft with an autonomous air-refueling capability, which would provide greater standoff capability, expanded payload and launch options, and increased naval reach and persistence. Following completion of the demonstration and technology maturation effort, the Navy will decide whether to initiate a formal acquisition program.



Source: Northrop Grumman.

### Current Status

The Navy UCAS-D program is a demonstration program. The program plans to demonstrate carrier operations, including autonomous aerial refueling, of a low-observable unmanned combat air system and mature both aircraft and other critical technologies needed to operate and integrate the aircraft with the ship. These efforts are intended to support an acquisition decision for a potential Navy UCAS major defense acquisition program, which could enter the acquisition process at either the technology demonstration or engineering and manufacturing development phase. In August 2007, the Navy awarded a cost-plus incentive fee contract to Northrop Grumman for the design, development, integration, test, and demonstration of two unmanned combat air systems. The contractor has completed the first air vehicle and is currently building the second air vehicle. First flight is scheduled for December 2010, and according to program officials, the demonstration effort—excluding the autonomous aerial refueling capability—is scheduled to be completed by 2013. The refueling capability is not scheduled to be demonstrated until summer 2014 and all technology maturation and demonstration efforts are to be completed by 2015.

While the prime contractor's estimated costs have grown by over \$200 million to \$813 million, according to the program manager, there is sufficient funding in the President's fiscal year 2011 budget request to complete the demonstration program. The cost of the prime contract has grown, in part, because the contractor originally proposed completing the demonstration sooner than 2013 and the Office of the Secretary of Defense added an autonomous aerial refueling demonstration to the program in 2008. Although the Navy officials initially agreed to the accelerated schedule, it was subsequently determined that the technology involved was more complex than originally anticipated. After a 2010 review by the Navy, the program's cost and schedule estimates were revised to reflect the Navy's original 2013 program completion date as well as the addition of the autonomous aerial refueling capability.

**Estimated Total Program Cost:** \$1,562.1 million

Quantities: 2

**Next Major Program Event:** First flight, December 2010

**Program Office Comments:** The Navy UCAS-D program office provided technical comments, which were incorporated as appropriate.

## Nett Warrior Increment I

The Army's Nett Warrior program is an integrated ground soldier system designed to provide embedded training and increased situational awareness, lethality, mobility, survivability, and sustainability during combat operations. There are three increments planned. Increment I will focus on developing the situational awareness system used initially with Stryker Brigade Combat Teams. The program is a descendant of the Land Warrior program, which was terminated due to cost concerns and funding constraints.



Source: U.S. Army.

### Current Status

The Nett Warrior program was approved to enter technology development in February 2009 and plans to proceed directly to production in fiscal year 2011. The Army has awarded cost-plus-fixed-fee contracts to General Dynamics, Raytheon, and Rockwell Collins for prototypes, which include a hands-free display, headset, computer, navigation equipment, antennas, and cables. These prototype designs have undergone developmental testing and are currently being evaluated in a limited user test. The Army has identified five critical technologies for Nett Warrior Increment I—energy/power management subsystem, antenna, navigation, user controller, and voice intelligibility. These technologies are currently nearing maturity and, pursuant to a program acquisition decision memorandum, they must be demonstrated in an operational environment prior to exiting technology development. Based on the results of the limited user test, conducted at Ft. Riley, Kansas, and a technology readiness assessment of the program by the Director, Defense Research and Engineering, the Under Secretary of Defense for Acquisition, Technology and Logistics will make a decision on whether the program will proceed to engineering and manufacturing development or directly to production and deployment as planned. While it is not designated as a critical technology, the fully networked capability of the Nett Warrior Increment I will not be achieved until the Joint Tactical Radio System is incorporated after full-rate production.

**Estimated Total Program Cost:** \$1,669.4 million

Research and development: \$179.8 million

Procurement: \$1,489.6 million

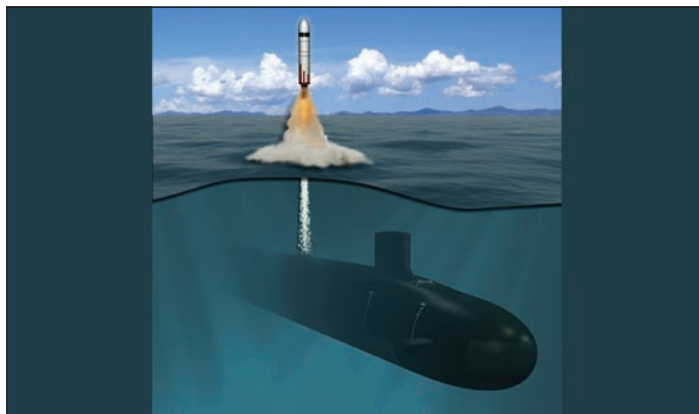
Quantities: 20,430

**Next Major Program Event:** Low-rate initial production decision, fiscal year 2011

**Program Office Comments:** The program office provided technical comments, which were incorporated as appropriate.

## Ohio-Class Replacement (OR) / Sea Based Strategic Deterrent

The Navy's Ohio-class Replacement (OR) / Sea Based Strategic Deterrent will replace the current fleet of Ohio-class ballistic missile submarines (SSBN) as they begin to retire in 2027. The Navy began research and development in 2008, in order to avoid a gap in sea-based nuclear deterrence between the Ohio class's retirement and the production of a replacement. The Navy is working with the United Kingdom to develop a Common Missile Compartment (CMC) for use on the Ohio-class replacement and the United Kingdom's replacement for the Vanguard SSBN.



Source: General Dynamics Electric Boat.

### Current Status

The OR program was scheduled to enter technology development in December 2010. The Navy's fiscal year 2011 long range shipbuilding plan includes 12 OR SSBNs and projects that the program will receive authorization to begin construction on the lead ship in fiscal year 2019. The high expected cost of the OR has been an early focus of the program. Both DOD and Navy officials have stated the cost of the program could dominate Navy shipbuilding budgets in the 2020 to 2030 time frame. The size and number of missile tubes is one of a number of cost drivers. The OR's analysis of alternatives, which was approved by the Office of the Secretary of Defense's office of Cost Analysis and Program Evaluation in December 2009, discussed the size and number of missile tubes; however, a final decision is still pending. According to the program office, Northrop Grumman, Babcock Integrated Technologies, Electric Boat Corporation, and BAE Systems Marine have been awarded contracts for assembly of prototype missile tubes.

The main focus of OR research and development to date has been the CMC. The United Kingdom has provided \$329 million for this effort since fiscal year 2008. During fiscal years 2009 and 2010, the Navy had allocated about \$183 million for the design and prototyping of the missile compartment. According to Navy officials, the program's other areas of emphasis include developing stealth technologies, ensuring a balanced ship design and the production readiness of the missile tube manufacturing base, and strengthening government system engineering personnel.

Overall, the Navy has received \$510.3 million for the OR program over fiscal years 2009 and 2010. The President's budget request for fiscal year 2011 included an additional \$672.3 million. These numbers include funding for OR and propulsion plant development.

### Estimated Total Program Cost: TBD

**Next Major Program Event:** Engineering and manufacturing development start, fiscal year 2015

**Program Office Comments:** The OR program generally concurred with this assessment. The program stated that over the past year, it has focused on containing nonrecurring engineering and construction costs by incorporating innovations to ship design and construction methodologies and practices as well as lessons learned from the Virginia-class program's design and construction. The program office also provided technical comments, which were incorporated as appropriate.

## Space Fence

The Air Force's Space Fence will be a new system of ground-based radars to replace the aging Air Force Space Surveillance System. It will use higher radio frequencies to detect and track smaller Earth-orbiting objects. The system will consist of up to two geographically dispersed radars (notionally located in Australia, Ascension Island, or Kwajalein Atoll) to help ensure effective space surveillance coverage. The system's enhanced capabilities are expected to significantly increase the number of orbiting objects detected and tracked.



Source: U.S. Air Force.

### Current Status

The Space Fence program began technology development in March 2009. In June 2009, the Air Force awarded three \$30 million firm fixed-price contracts to Lockheed Martin, Northrop Grumman, and Raytheon. The Northrop Grumman contract was subsequently terminated after a reduction in program funding. The program is currently focused on making cost, schedule, and performance tradeoffs to ensure its affordability. The Air Force next plans to conduct a full and open competition and award up to two contracts for a maximum of \$214 million to continue technology development. The contracts will go through the preliminary design review, which is planned for January 2012, followed by another full and open competition leading to a single, final development and production contract in July 2012. The first Space Fence radar site is scheduled to provide initial operational capability by the end of fiscal year 2015, with the final site providing full capability by 2020.

The program office identified five critical technologies and expects them to be nearing maturity by the preliminary design review. Mature backup technologies exist; however, all have potentially higher acquisition or operating costs associated with them, or both. According to the program office, using these backups could make the program unaffordable.

According to the program office, a separate program for the development of a new space command and control system poses a risk for Space Fence. This new system, which will process Space Fence data, needs to be available when the Space Fence is fielded because the amount of data it will generate exceeds existing command and control system performance limits.

**Estimated Total Program Cost:** \$2,717.6 million

Research and development: \$1,682.2 million

Procurement: \$1,035.4 million

Quantities: 1 (Research and Development), 1 (Procurement)

**Next Major Program Event:** Final development and production start, July 2012

**Program Office Comments:** The program office stated that changes to the acquisition strategy increase competition, induce further contractor design and cost realism, and reduce program risk to deliver the first system capability by September 2015. The preliminary design review is expected to occur 6 months prior to the planned June 2012 milestone B, allowing for a more informed decision at final contract award. The program office also provided technical comments, which were incorporated as appropriate.



## Stryker Modernization (SMOD)

The Army's Stryker family of vehicles is a group of deployable, wheeled, armored vehicles. The Stryker upgrade program, commonly known as Stryker Modernization, is a technological overhaul of targeted components designed to improve the vehicle's survivability, mobility, lethality, and networking capabilities. The system enhancements, which will be applied to all 10 Stryker variants, will enable the vehicles to remain in operation through 2050. The program will comprise two increments. We made observations on increment one.



Source: U.S. Army.

### Current Status

The Army is planning a materiel development decision (MDD) for the Stryker Modernization program, which will determine where it will enter the acquisition process. The program is the outgrowth of a modernization concept that was briefed at a Stryker configuration steering board meeting in August 2009. According to the Stryker program, the modernization program is necessary to address space, weight, and power constraints that could affect the vehicles' ability to meet current and future warfighting needs. Before moving forward with the program, the Army had to await the outcome of two events. In March 2010, the Under Secretary of Defense for Acquisition, Technology and Logistics directed the Army to provide a complete overview of Stryker Modernization efforts, including an evaluation of how Stryker Modernization activities fit into the Army strategy for meeting future ground combat vehicle requirements. In addition, the Army must complete its combat vehicle portfolio review.

The first increment of the Stryker Modernization program will consist of two phases. According to program officials, phase 1 will focus on the common characteristics of all 10 variants, such as the chassis and drive train, spare parts, and test equipment. Phase 2 will focus on enhancing characteristics unique to each of the variants, such as fire support and medical evacuation. The Army has identified three critical technologies for phase 1—semiactive suspension, survivability improvements, and power generation. According to the program, all three technologies will be demonstrated in a relevant or realistic environment before the program enters engineering and manufacturing development. The program also plans to select, through competition, three contractors to develop prototypes of key subsystems prior to this phase. Additional critical technologies may be identified for phase 2. The Stryker Modernization strategy will be determined by Army senior leaders and then that strategy will be recommended to the defense acquisition executive at the program's MDD for his approval.

**Estimated Total Program Cost:** \$2,179.8 million

Research and development: \$1,190.0 million

Procurement: \$989.8 million

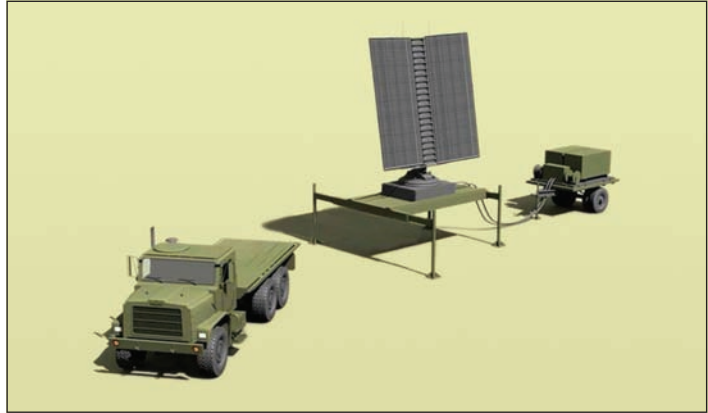
Quantities: 35 (Research and Development), 664 (Procurement)

**Next Major Program Event:** Materiel development decision, TBD

**Program Office Comments:** In commenting on a draft of this assessment, the Army provided technical comments, which were incorporated as appropriate.

## Three Dimensional Expeditionary Long Range Radar (3DELRR)

The Air Force's 3DELRR will be the long-range, ground-based sensor for detecting, identifying, tracking, and reporting aircraft and missiles for the Joint Forces Air Component Commander. It will provide real-time data and support a range of expeditionary operations in all types of weather and terrain. It is being acquired to replace the Air Force's AN/TPS-75 radar systems. The Marine Corps is considering 3DELRR as a potential replacement to the AN/TPS-59 to support the Marine Air-Ground Task Force Commander.



Source: U.S. Air Force.

### Current Status

The 3DELRR program was approved to enter the technology development phase in May 2009. The Air Force has awarded firm fixed-price contracts for the development of system-level prototypes. The program expects to demonstrate the capability of each of the prototypes by the end of the first quarter of fiscal year 2011. The program plans to conduct a full and open competition and award a single cost plus incentive fee contract for program definition and risk reduction before seeking approval to enter engineering and manufacturing development in the third quarter of fiscal year 2013. Initial operational capability for the radar is targeted for approximately 2019.

The 3DELRR program is focused on reducing technical risk before beginning system development. The program has identified six critical technologies. The program's technology development strategy calls for these technologies to be nearing maturity and demonstrated in a relevant environment by the start of system development. The program also expects to complete a preliminary design review prior to development start and a critical design review early in the engineering and manufacturing development phase.

According to the program office, the primary risks going forward are securing adequate funding and accurately capturing the user's requirements. Additional near-term funding is necessary to execute the current acquisition strategy. In the event of a program budget shortfall, the program office would have to examine alternatives including revising the acquisition strategy, conducting requirements tradeoffs, and extending the delivery schedule. Further, if the program's requirements document does not accurately represent user requirements, then the system design could require changes late in the acquisition process.

**Estimated Total Program Cost:** \$2,092.4 million

Research and development: \$743.3 million

Procurement: \$1,349.1 million (Air Force only)

Quantities: 35 (Air Force only)

**Next Major Program Event:** Program definition and risk reduction contract award, second quarter fiscal year 2012

**Program Office Comments:** The program office concurred with the assessment and provided technical comments, which we incorporated as appropriate.

## V-22 Joint Services Advanced Vertical Lift Aircraft (Osprey)

The V-22 Osprey is a tilt-rotor aircraft developed for use by the Marine Corps, Air Force, and Navy. The Marine Corps and Air Force Special Operations Command have completed multiple deployments of the MV-22 and CV-22, respectively, in Iraq, Africa, Afghanistan, South America, and in support of the humanitarian efforts in Haiti. As of December 2010, there were 125 V-22s in service. The program is currently focused on improving readiness, decreasing ownership cost, and preparing for a second multi-year procurement contract.



Source: U.S. Marine Corps.

### Current Status

The V-22 has been deployed and is supporting combat operations; however, the aircraft has experienced reliability and readiness issues that have resulted in high maintenance and operating costs. Since 2009, the program has undertaken several initiatives to understand and reduce operations and maintenance costs after it became apparent the MV-22 was exceeding its budgeted cost per flight hour. The program developed a new cost model to increase the quality and accuracy of cost per flight hour estimates and established a team to identify cost savings opportunities. According to the Marine Corps, it is also working with industry to increase the durability of key components that affect readiness and operating costs. One of the program's top priorities is the ice protection system. A June 2010 Air Force accident report on a March 2009 CV-22 engine failure concluded that it was caused by a part from the central deice distributor (an ice protection system component) shaking loose and falling into the engine. The report stated that this part had a history of structural issues related in part to its design. The program office has addressed the risks identified in the report by instituting an inspection of this component at the 35 hour interval and installing a more durable version of the part on aircraft in production. According to the program office, all CV-22s and deployed MV-22s have been retrofitted with the hardware fix and retrofit kits are available for the remaining fleet. In April 2010, a CV-22 crashed on an infiltration mission in support of ground forces in Afghanistan. In August 2010, the Air Force Accident Investigation Board reported that there were 10 substantially contributing factors to the accident and that they fell into four categories: mission execution, environmental conditions, human factors, and aircraft performance. We were unable to follow-up on how these factors are being addressed during our assessment. The V-22 program is in the fourth year of its first multiyear procurement contract. The program will request authority to enter, and is planning and budgeting for, a second multiyear procurement contract to begin in fiscal year 2013.

**Estimated Total Program Cost:** \$56,061.1 million

Research and development: \$13,114.7 million

Procurement: \$42,829.3 million

Quantities: 458 aircraft

**Program Office Comments:** In its comments on a draft of this assessment, the program office stated that the V-22 has met all operational tasking and the Marines and Air Force are exceptionally satisfied with the V-22's "game changing" capabilities. It also emphasized the aircraft's exceptional survivability and the numerous improvements that have been made to it in the last decade. Eight Marine and two Air Force Osprey squadrons are operational. The program projects reaching 100,000 flight hours in early 2011. Production is fully mature with aircraft deliveries on or ahead of schedule. The program's overall strategy is an effective and affordable globally deployed Osprey fleet.



## Presidential Helicopter (VXX)

The Navy's VXX program is expected to develop and field a replacement for the current fleet of VH-3D and VH-60N helicopters that provide transportation for the President, Vice President, heads of state, and others as directed. The program was initiated after the VH-71 presidential helicopter replacement program was terminated in June 2009 due to excessive cost growth and schedule delays. The Navy is also taking steps to extend the service life of its existing fleet of VH-3D and VH-60N helicopters until a new helicopter can be fielded.



Source: U.S. Navy.

### Current Status

In March 2010, the VXX program held a materiel development decision review. The Navy expects to complete an analysis of alternatives by the second quarter of fiscal year 2011 and enter technology development by the third quarter of fiscal year 2011. According to program officials, the new program will complete a four-phase systems engineering and design review process before beginning system development.

In June 2009, DOD terminated the VH-71 program due to excessive cost growth, schedule delays, and technical risk. From its inception, program officials had acknowledged that the program carried substantial risk due to an aggressive schedule directed by the White House. Program officials further attribute the program's problems to a misunderstanding between the government and contractors over requirements—a problem exacerbated by a highly compressed development schedule, a lack of sufficient predevelopment systems engineering and design work, and the eventual reengineering of entire subsystems needed to mitigate aircraft performance and weight issues. Prior to termination, five pilot production VH-71s were built and delivered and 10 percent of the planned 1,460 flight hour test program was completed.

As a result of the VH-71 termination, the Navy has to extend the service life of its fleet of VH-3D and VH-60N helicopters. Current projections indicate these helicopters can operate until 2017; however, the Navy is studying whether the fleet's life can be extended to 2023 or later until the VXX is fielded.

**Estimated Total Program Cost:** TBD

**Quantities:** TBD

**Next Major Program Event:** Technology development start, third quarter fiscal year 2011

**Program Office Comments:** The program office concurred with this assessment.

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## Agency Comments and Our Evaluation

DOD provided us with written comments on a draft of this report. The comments are reprinted in appendix VI. DOD also provided technical comments, which we addressed in the report, as appropriate.

In its comments, DOD stated that it did not find GAO's methods for calculating cost growth useful for management purposes. Specifically, DOD takes exception to the part of our analysis that aggregates data on the cost growth that has accumulated from a program's first full cost estimate, which is typically tied to the start of development—milestone B—to the current year. DOD considers our methodology to be flawed and the resulting information to be misleading because it does not delineate cost growth experienced in the past, cost growth associated with capability upgrades, and cost growth associated with quantity increases. DOD requested that those metrics be removed from the report. In addition, DOD commented that the four different cost growth metrics presented in the report make it difficult for readers to gain an understanding of program performance.

Given the magnitude and complexity of major weapon system acquisitions, we believe no single metric adequately captures all of the dynamics of cost changes. Measuring cost increases from the formal start of a program to the present is one of several important metrics because it conveys the magnitude of the task at hand and provides a context for management. Further, milestone B is recognized as a key point for establishing accountability for weapon system programs, as evidenced by the importance of milestone B cost estimates in reporting Nunn-McCurdy unit cost breaches to Congress and the statutory certification requirements a program must meet, which include developing a reasonable cost estimate, to proceed beyond this point. Therefore, we retained this as one of several metrics used to measure program performance in this report. With regard to DOD's comment about cost growth associated with capability upgrades, we believe that a key tenet of a knowledge-based acquisition approach is to set realistic capability requirements at the outset of a program and to avoid changing them in order to achieve cost and schedule predictability.

We used several other metrics to make distinctions between older and more recent cost increases and increases stemming from a lack of knowledge or poor program management versus simple quantity increases. For example, we designed our cost analysis to focus primarily on program performance over the last 2 years, which allows us to evaluate DOD's management of its major defense acquisition programs since key

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acquisition reforms were put into place by Congress and DOD. To ensure the focus remains on this 2-year analysis, we made changes to table 2 in the final report in response to DOD's comments. Our analysis also explicitly accounts for cost increases associated with changes in weapon system quantities including cases such as the DDG 51 and the MRAP. Similarly, we present analysis of the often-overlooked and hard-to-quantify phenomenon of reducing quantities or capabilities, or both, to offset cost increases.

DOD also commented on a set of program performance metrics that were discussed by DOD, OMB, and GAO in 2008, as a mechanism for evaluating DOD's progress in addressing the issues discussed in GAO's Weapon Systems Acquisition High-Risk area. DOD believes that these metrics still do not adequately capture cost growth that results solely from poor estimating and poor execution as opposed to other sources including changes in inventory goals and changes in requirements or capabilities. We agree that these metrics do not quantify the cost growth attributable to each of those factors; however, DOD specifically requested that we use these metrics to assess the performance of its major defense acquisition program portfolio and its policies in its comments on our 2009 and 2010 annual assessments of weapon programs. We will continue to work with DOD to develop a set of metrics to better measure its progress in addressing its long-standing weapon system acquisition issues. Finally, DOD stated that it is undertaking a series of actions to obtain greater efficiency and productivity in defense spending. We support DOD's efforts to get better value from defense spending and look forward to including the results of these efforts in future reports.

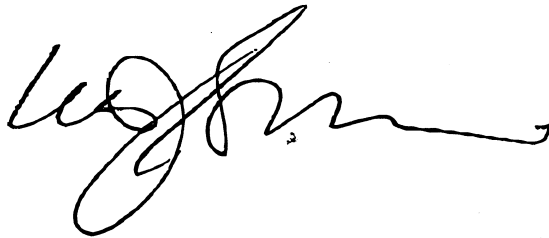
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We are sending copies of this report to the Secretary of Defense; the Secretaries of the Army, Navy, and Air Force; and the Director of the Office of Management and Budget. In addition, the report will be made available at no charge on the GAO Web site at <http://www.gao.gov>.

If you or your staff have any questions concerning this report, please contact me at (202) 512-4841. Contact points for our offices of Congressional Relations and Public Affairs may be found on the last page

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of this report. Staff members making key contributions to this report are listed in appendix VII.

A handwritten signature in black ink, appearing to read 'Michael J. Sullivan', with a large loop at the end.

Michael J. Sullivan  
Director, Acquisition and Sourcing Management

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*List of Committees*

The Honorable Carl Levin  
Chairman  
The Honorable John McCain  
Ranking Member  
Committee on Armed Services  
United States Senate

The Honorable Daniel Inouye  
Chairman  
The Honorable Thad Cochran  
Ranking Member  
Subcommittee on Defense  
Committee on Appropriations  
United States Senate

The Honorable Howard P. McKeon  
Chairman  
The Honorable Adam Smith  
Ranking Member  
Committee on Armed Services  
House of Representatives

The Honorable C.W. Bill Young  
Chairman  
The Honorable Norman D. Dicks  
Ranking Member  
Subcommittee on Defense  
Committee on Appropriations  
House of Representatives

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# Scope and Methodology

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This report contains observations on the performance of the Department of Defense's (DOD) fiscal year 2010 major defense acquisition program portfolio. To develop these observations, we obtained and analyzed data from Selected Acquisition Reports (SAR) and other information in the Defense Acquisition Management Information Retrieval Purview system, referred to as DAMIR.<sup>1</sup> We refer to programs with SARs dated December 2009 as the 2010 portfolio. We converted cost information to fiscal year 2011 dollars using conversion factors from the DOD Comptroller's National Defense Budget Estimates for Fiscal Year 2011 (table 5-9). Data for the total planned investment of major defense acquisition programs were obtained from DAMIR, which we aggregated for all programs using fiscal year 2011 dollars. However, the data do not include the full costs of acquiring Missile Defense Agency (MDA) programs.

We also collected and analyzed data on the composition of DOD's major defense acquisition program portfolio. To determine changes in that portfolio, we compared the programs that issued SARs in December 2009 with the list of programs that issued SARs in December 2007. To assess the cost effect of changes to the major defense acquisition portfolio, we calculated the estimated total acquisition cost for the 13 programs exiting the portfolio and for the 15 programs entering the portfolio.

To compare the cost of major defense acquisition programs over 2 years, 5 years, and from baseline estimates, we collected data from December 2009, December 2007, and December 2004 SARs; acquisition program baselines; and program offices. We retrieved data that showed cost estimates for research, development, test, and evaluation; procurement; and total acquisition for 98 major defense acquisition programs in the 2010 portfolio. We divided some SAR programs into smaller elements, because DOD reports performance data on them separately. We analyzed the data to determine the change in research and development, procurement, and total acquisition costs from the first full estimate, generally development start, with the current estimate. For a few programs that did not have a development estimate, we compared the current estimate to the production estimate. Also, for a few shipbuilding programs that had a full planning estimate, we compared the current estimate to the planning estimate. For programs that began as non-major defense acquisition

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<sup>1</sup>DAMIR Purview is an executive information system operated by the Office of the Under Secretary of Defense for Acquisition, Technology and Logistics / Acquisition Resources and Analysis.



programs, the first full estimate used by GAO as a baseline may be different than the original baseline contained in DOD SARs. When comparable cost and schedule data were not available for programs, we excluded them from the analysis. To calculate cost growth incurred over the past 2 years, from 2008 to 2010, we calculated the difference between the December 2007 and December 2009 SARs for programs older than 2 years. For programs less than 2 years old, we calculated the difference between December 2009 and first full estimates. We converted all dollar figures to fiscal year 2011 constant dollars. We took a similar approach for calculating cost growth incurred from 2005 to 2010. We also obtained schedule information and calculated the time since program start, or program age; cycle time from program start to initial operational capability; delay in obtaining initial operational capability; and the delay in initial capability as a percentage of total cycle time. Finally, we extracted data on quantities and program acquisition unit cost and compared the current unit cost to the baseline unit cost to determine whether programs' unit cost has increased or decreased from the baseline estimate. For three software programs with no quantities, we assigned each program a quantity of one. For two programs, F-22 and DDG 51, we then calculated the effect on DOD's buying power from each program by multiplying the change in program acquisition unit cost by the current planned quantities.

To calculate the amount of procurement cost growth attributable to quantity increases, we isolated the change in procurement costs and the change in procurement quantities for programs over the past 2 years. For those programs with change in procurement quantities, we calculated the amount attributable to quantity changes as the change in quantity multiplied by the average procurement unit cost for the program 2 years ago.

To evaluate program performance according to DOD, OMB, and GAO-developed metrics, we calculated how many programs had less than a 4 percent increase in total acquisition cost over the past 2 years, less than a 10 percent increase over the past 5 years, and less than a 15 percent increase from initial estimates using data from December 2009, December 2007, and December 2004 SARs; acquisition program baselines; and program offices. For programs that began as non-major defense acquisition programs, the first full estimate used by GAO as a baseline may be different than the original baseline contained in DOD SARs. We also identified 10 of the highest cost programs from the December 2009 SARs and calculated changes in total costs and program acquisition unit cost over the past 2 years. We excluded MDA's Ballistic Missile Defense System

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from this analysis, because the program does not report baseline estimates or quantity information in its annual SAR.

To calculate the amount of cost growth incurred before and after production start, we identified 56 programs with December 2009 SARs that had production cost estimates. To determine the average age of these programs, we calculated the time between program start and December 2009 for each program. To analyze the cost growth before and after production, we compared development cost estimates, production cost estimates, and December 2009 cost estimates for both research and development and procurement costs and determined the difference between each estimate for each program. We then calculated the percent change between development and production estimates, and between production and current estimates for both development and procurement costs. Finally, we calculated the average percent change for each program from development to production and from production to current estimates to determine the average percent cost growth incurred before and after production.

Through discussions with DOD officials responsible for the database and confirming selected data with program offices, we determined that the SAR data and the information retrieved from DAMIR were sufficiently reliable for our purposes.

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## Analysis of Selected DOD Programs Using Knowledge-Based Criteria

In total, this report presents information on 71 weapon programs. A table listing these programs is found in appendix VII. Out of these programs, 49 are captured in a two-page format discussing technology, design, and manufacturing knowledge obtained and other program issues. The remaining 22 programs are described in a one-page format that describes their current status. We chose these programs based on their estimated cost, stage in the acquisition process, and congressional interest. To obtain cost, schedule, technology, design, and manufacturing information, we asked 49 programs to complete a data-collection instrument and received responses from all these programs. In addition, to collect information from major defense acquisition programs and components of these programs on other program factors such as requirements changes, configuration steering board activities, software development, and program office staffing, we asked 44 programs to complete a second electronic questionnaire and received responses from all these programs from June to November 2010. To collect data from pre-major defense acquisition programs including cost and schedule estimates, technology maturity, and

planned implementation of acquisition reforms, we distributed a separate electronic questionnaire to 54 programs categorized as pre-major defense acquisition programs as of July 2010. Both questionnaires were sent by e-mail in an attached Microsoft Word form that respondents could return electronically. We received responses from June to November 2010. During the course of our review, we dropped 37 programs from this analysis, including 19 that were no longer slated to become major defense acquisition programs, 11 that had not yet begun the technology development phase, and 7 that had become major defense acquisition programs or were spinoffs of major defense acquisition programs. In addition, three programs did not return the questionnaire. Therefore, our assessment of planned major defense acquisition programs consists of 14 programs nearing system development start. To ensure the reliability of the data collected through our questionnaires, we took a number of steps to reduce measurement error, nonresponse error, and respondent bias. These steps included conducting two pretests of each questionnaire by phone prior to distribution to ensure that our questions were clear, unbiased, and consistently interpreted; reviewing responses to identify obvious errors or inconsistencies; conducting follow-up to clarify responses when needed; and verifying the accuracy of a sample of keypunched questionnaires.

Our analysis of how well programs are adhering to a knowledge-based acquisition approach focuses on a subset of 40 major defense acquisition programs from DOD's fiscal year 2010 portfolio that were in development or the early stages of production as of June 2010. The 31 programs that are not included in this analysis either do not have acquisition milestones that line up with development start, critical design review, and production start or lack key data on technology, design, and production necessary to assess them against our knowledge-based acquisition criteria at this point in time.<sup>2</sup>

To assess the cost and schedule outcomes for the 40 programs to-date, we identified programs with cost, schedule, and quantity data at the first full estimate, generally milestone B—development start—and the estimate from the December 2009 SAR. Of the programs in our assessment, 39 had relevant data on research and development costs, 38 had relevant data on procurement costs, and 34 had data on schedules for delivering initial

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<sup>2</sup>The 31 programs in our assessment that are not covered in this analysis include: 18 planned major defense acquisition programs, 4 MDA elements, 4 programs that are well into production, 1 component within a major defense acquisition program, 1 program that is based on a commercially-derived aircraft, 2 programs that were canceled, and 1 technology development program.

capabilities. The remaining programs, not included in this analysis, did not have comparable data. We summed the first full estimate and the current estimate of both research and development costs and procurement costs for the programs and calculated the percentage change between the estimates. The schedule assessment is calculated two ways—as the average of the change in months between the first and current estimates for the planned or actual delivery of initial operational capability and as the average change in months divided by the first estimate of acquisition cycle time.

To assess knowledge attainment of programs at critical decision points (system development start, critical design review, and production start), we collected data about their knowledge levels at each point. The data were collected from 40 program offices as of November 2010. Additional information on product knowledge is found in the product knowledge assessment section of this appendix. We did not validate the data provided by the program offices, but reviewed the data and performed various checks to determine that they were reliable enough for our purposes. Where we discovered discrepancies, we clarified the data accordingly. Programs in our assessment were in various stages of the acquisition cycle, and not all of the programs provided knowledge information for each point. Programs were not included in our assessments if relevant decision or knowledge point data were not available. In addition, because knowledge points differ for shipbuilding programs, we exclude them from our assessment of certain knowledge-based practices. In particular, we focused on the 17 programs that entered these key acquisition points since 2009 and evaluated their adherence to knowledge-based practices. For each decision point, we summarized knowledge attainment for the number of programs with data that achieved that knowledge point. Twenty-six nonship programs provided data on technology maturity at development start, 1 of which began development since 2009; 29 nonship programs provided data on design stability at their critical design review, 9 of which held this review since 2009; and 4 programs provided data on production processes in control at production start, 1 of which began production since 2009. Our analysis of knowledge attained at each key point also includes other factors that we have previously identified as being key to a knowledge-based acquisition approach, including holding system design reviews early in development, planning for manufacturing, testing an integrated prototype prior to the design review, using a reliability growth curve, and testing a production-representative prototype prior to making a production decision. See appendix IV for a list of these practices.

For our analysis of requirements changes, we obtained and analyzed information from 39 programs about the number and effect of requirements changes since development start. Using this information, we compared the average percent change in research and development cost and delay in delivery of an initial operational capability between programs that had an added or enhanced key performance parameter; a reduced, deferred, or deleted key performance parameter; or stable key performance parameters. We also compared the age of programs that had stable or unstable requirements.

For our analysis of software development, we obtained and analyzed information from 25 programs related to the number of software lines of code expected in the final system at development start and currently, and from 21 programs that collect data on the percentages of software defects contained in-phase and in subsequent phases. We also collected data from 40 programs on whether they collected earned value management data for software development. We calculated whether the percentage growth in total lines of code correlated with the percentage growth in research and development costs, as well as whether the growth in software correlated with percentage delay in achieving initial operational capabilities. We also compared the total lines of code expected currently with whether programs are collecting earned value management data for software development. Finally we compared the percentage growth in software lines of code with program age.

For our analysis of program staffing, we analyzed information related to program office staffing from 44 programs, including 40 major defense acquisition programs and 4 MDA elements, on the number of military personnel, civilian government employees, support contractors, and Federally Funded Research and Development Centers and university-affiliated employees working in the following functions: program management, business-related functions, contracting, engineering, administrative support, and other functions. We compared this information with data collected in prior years. We also collected information on whether programs had been authorized all positions requested, whether they had filled those positions, reasons for not filling positions, and whether they were using support contractors to make up for shortfalls in government personnel or capabilities.

To determine how DOD has begun to implement acquisition reforms, we obtained and analyzed the revised DOD 5000.02 acquisition instruction, the Weapon Systems Acquisition Reform Act of 2009, and the Directive-Type

Memorandum 09-027 implementing the Act. We analyzed data from the survey sent to planned major defense acquisition programs in our assessment to determine how they were implementing requirements for holding a preliminary design review; developing prototypes; maturing critical technologies; and considering tradeoffs among cost, schedule, and performance objectives before development start. We also collected information on whether these programs are planning to incorporate competition into their acquisition strategies.<sup>3</sup> To determine how programs were implementing the requirement to hold configuration steering boards, we analyzed data from the survey sent to major defense acquisition programs.

We relied on GAO's body of work examining DOD acquisition issues over the years. In recent years, we have issued reports that identified systemic problems with major weapon systems acquisitions and we have made recommendations to DOD on ways to improve how it acquires major weapon systems. These reports cover contracting, program management, acquisition policy, cost estimating, budgeting, and requirements development. We have also issued many detailed reports evaluating specific weapon systems, such as aircraft programs, ships, communication systems, satellites, missile defense systems, and future combat systems. We also used information from numerous GAO products that examine how commercial best practices can improve outcomes for DOD programs. This work has shown that valuable lessons can be learned from the commercial sector and can be applied to the development of weapon systems.

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## System Profile Data on Each Individual Two- Page Assessment

Over the past several years, DOD has revised policies governing weapon system acquisitions and changed the terminology used for major acquisition events. To make DOD's acquisition terminology more consistent across the 71 program assessments, we standardized the terminology for

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<sup>3</sup>The DOD and statutory requirement is that the acquisition strategy for each major defense acquisition program include measures to ensure competition, or the option of competition, throughout the life cycle of the program. Weapon Systems Acquisition Reform Act of 2009, Pub. L. No. 111-23, § 202; Under Secretary of Defense, Acquisition, Technology and Logistics Directive-Type Memorandum (DTM) 09-027—Implementation of the Weapon Systems Acquisition Reform Act of 2009, attachment 1, para. 2 (Dec. 4, 2009). The survey question with respect to this requirement read "Does the acquisition strategy call for competition post-Milestone B." When programs answered "no" to the question, GAO interpreted that answer to mean that the program is not planning to incorporate into the acquisition strategy competition, or the option of competition, after development start.

key program events. For most individual programs in our assessment, “development start” refers to the initiation of an acquisition program as well as the start of engineering and manufacturing development. This coincides with DOD’s milestone B. A few programs in our assessment (mostly programs that began before 2001) have a separate “program start” date, which begins a pre-system development phase for program definition and risk-reduction activities. This “program start” date generally coincides with DOD’s former terminology for milestone I, followed by a “development start” date, either DOD’s former milestone II or current milestone B depending on when the program began system development. The “production decision” generally refers to the decision to enter the production and deployment phase, typically with low-rate initial production. The “initial capability” refers to the initial operational capability—sometimes called first unit equipped of required asset availability. For shipbuilding programs, the schedule of key program events in relation to acquisition milestones varies for each program. Our work on shipbuilding best practices has identified the detailed design and construction contract award and the start of lead ship fabrication as the points in the acquisition process roughly equivalent to development start and design review for other programs. For MDA programs that do not follow the standard DOD acquisition model but instead develop systems’ capabilities incrementally, we identify the key technology development efforts that lead to an initial capability.

For each program we assessed in a two-page format, we present cost, schedule, and quantity data at the program’s first full estimate, generally milestone B, and an estimate from the program office reflecting 2010 data where it was available. To assess the cost, schedule, and quantity changes of each program, we reviewed DOD’s SARs or obtained data directly from the program offices. In general, we compared the latest available SAR information with a baseline for each program. For programs that have started product development—those that are beyond milestone II or B—we compared the latest available SAR to the development estimate from the first SAR issued after the program was approved to enter development, or for the planning estimate if we had a full estimate. For systems not included in the SARs, we attempted to obtain comparable baseline and current data from the individual program offices. For MDA systems, for which a baseline was not available, we do not present a comparison. For the other programs assessed in a one-page format, we present the latest available estimate of cost and quantity from the program office.



For each program we assessed, all cost information is presented in fiscal year 2011 dollars using Office of the Secretary of Defense–approved deflators to eliminate the effects of inflation. We have depicted only the program’s main elements of acquisition cost—research and development and procurement. However, the total program cost also includes military construction and acquisition operation and maintenance costs. Because of rounding and these additional costs, in some situations, total cost may not match the exact sum of the research and development and procurement costs. The program unit costs are calculated by dividing the total program cost by the total quantities planned. In some instances, the data were not applicable, and we annotate this by using the term “not applicable (NA).” The quantities listed refer to total quantities, including both procurement and development quantities.

The schedule assessment for each program is based on acquisition cycle time, defined as the number of months between program start and the achievement of initial operational capability or an equivalent fielding date. In some instances the data were not yet available, and we annotate this by using the term “to be determined (TBD)” or “NA.”

The information presented on the “funding needed to complete” is from fiscal year 2011 through completion and, unless otherwise noted, draws on information from SARs or on data from the program office. In some instances, the data were not available, and we annotate this by the term “TBD” or “NA.” The quantities listed refer only to procurement quantities. Satellite programs, in particular, produce a large percentage of their total operations units as development quantities, which are not included in the quantity figure.

The intent of these comparisons is to provide an aggregate, or overall, picture of a program’s history. These assessments represent the sum of the federal government’s actions on a program, not just those of the program manager and the contractor. DOD does a number of detailed analyses of changes that attempt to link specific changes with triggering events or causes. Our analysis does not attempt to make such detailed distinctions.

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## Product Knowledge Data on Individual Two-Page Assessments

In our past work examining weapon acquisition issues and best practices for product development, we have found that leading commercial firms pursue an acquisition approach that is anchored in knowledge, whereby high levels of product knowledge are demonstrated by critical points in the acquisition process. On the basis of this work, we have identified three key

knowledge points during the acquisition cycle—development start; design review, which occurs during engineering and manufacturing development; and production start—at which programs need to demonstrate critical levels of knowledge to proceed. To assess the product development knowledge of each program at these key points, we submitted a data-collection instrument to 49 program offices. We received responses from all 49 programs; however, not every program had responses to each element of the data-collection instrument. The results are graphically depicted in each two-page assessment. We also reviewed pertinent program documentation and discussed the information presented on the data-collection instrument with program officials as necessary.

To assess technology maturity, we asked program officials to apply a tool, referred to as Technology Readiness Levels (TRL), for our analysis. The National Aeronautics and Space Administration originally developed TRLs, and the Army and Air Force science and technology research organizations use them to determine when technologies are ready to be handed off from science and technology managers to product developers. TRLs are measured on a scale from 1 to 9, beginning with paper studies of a technology's feasibility and culminating with a technology fully integrated into a completed product. See appendix V for TRL definitions. Our best practices work has shown that a technology readiness level of 7—demonstration of a technology in a realistic environment—is the level of technology maturity that constitutes a low risk for starting a product development program.<sup>4</sup> For shipbuilding programs, we have recommended that this level of maturity be achieved by the contract award for detailed design and construction.<sup>5</sup> In our assessment, the technologies that have reached TRL 7, a prototype demonstrated in a realistic environment, are referred to as mature or fully mature. Those technologies that have reached TRL 6, a prototype demonstrated in a relevant environment, are referred to as approaching or nearing maturity and are assessed at attaining 50 percent of the desired level of knowledge. Satellite technologies that have achieved TRL 6 are assessed as fully mature due to the difficulty of demonstrating maturity in a realistic environment—space.

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<sup>4</sup>GAO, *Best Practices: Better Management of Technology Development Can Improve Weapon System Outcomes*, [GAO/NSIAD-99-162](#) (Washington, D.C.: July 30, 1999); *Best Practices: Better Matching of Needs and Resources Will Lead to Better Weapon System Outcomes*, [GAO-01-288](#) (Washington, D.C.: Mar. 8, 2001).

<sup>5</sup>GAO, *Best Practices: High Levels of Knowledge at Key Points Differentiate Commercial Shipbuilding from Navy Shipbuilding*, [GAO-09-322](#) (Washington, D.C.: May 13, 2009).

In most cases, we did not validate the program offices' selection of critical technologies or the determination of the demonstrated level of maturity. We sought to clarify the TRLs in those cases where information existed that raised concerns. If we were to conduct a detailed review, we might adjust the critical technologies assessed, their readiness levels demonstrated, or both. It was not always possible to reconstruct the technological maturity of a weapon system at key decision points after the passage of many years. Where practicable, we compared technology assessments provided by the program office to assessments conducted by officials from the Office of the Director, Defense Research and Engineering.

To assess design stability, we asked program officials to provide the percentage of engineering drawings completed or projected for completion by the design review, the production decision, and as of our current assessment.<sup>6</sup> In most cases, we did not verify or validate the percentage of engineering drawings provided by the program office. We clarified the percentage of drawings completed in those cases where information that raised concerns existed. Completed drawings were defined as the number of drawings released or deemed releasable to manufacturing that can be considered the "build to" drawings. For shipbuilding programs, we asked program officials to provide the percentage of the 3D product model that had been completed by the start of lead ship fabrication, and as of our current assessment.<sup>7</sup>

To assess production maturity, we asked program officials to identify the number of critical manufacturing processes and, where available, to quantify the extent of statistical control achieved for those processes.<sup>8</sup> In most cases, we did not verify or validate the information provided by the program office. We clarified the number of critical manufacturing processes and the percentage of statistical process control where information existed that raised concerns. We used a standard called the Process Capability Index, a process performance measurement that quantifies how closely a process is running to its specification limits. The index can be translated into an expected product defect rate, and we have found it to be a best practice. We sought other data, such as scrap and

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<sup>6</sup>GAO, *Best Practices: Capturing Design and Manufacturing Knowledge Early Improves Acquisition Outcomes*, [GAO-02-701](#) (Washington, D.C.: July 15, 2002).

<sup>7</sup>GAO-09-322.

<sup>8</sup>GAO-02-701.

rework trends in those cases where quantifiable statistical control data were unavailable. We do not assess production maturity for shipbuilding programs.

Although the knowledge points provide excellent indicators of potential risks, by themselves they do not cover all elements of risk that a program encounters during development, such as funding instability. Our detailed reviews on individual systems normally provide a more comprehensive assessment of risk elements.

We conducted this performance audit from June 2010 to March 2011, in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

# Changes in DOD’s 2010 Portfolio of Major Defense Acquisition Programs over Time

Table 4 shows the change in research and development costs, procurement costs, total acquisition cost, and average delay in delivering initial operational capability for the Department of Defense’s (DOD) 2010 portfolio of major defense acquisition programs. The table presents changes that have occurred on these programs in the last 2 years, the last 5 years, and since their first full cost and schedule estimates.

**Table 4: Changes in DOD’s 2010 Portfolio of Major Defense Acquisition Programs over Time**

Fiscal year 2011 dollars in billions			
	Last 2 years (2008 to 2010)	Last 5 years (2005 to 2010)	Since first full estimate (Baseline to 2010)
Increase in total research and development cost	\$15 5 percent	\$29 10 percent	\$102 47 percent
Increase in total procurement cost	\$121 11 percent	\$186 18 percent	\$287 31 percent
Increase in total acquisition cost	\$135 9 percent	\$217 16 percent	\$402 35 percent
Average delay in delivering initial capabilities	5 months 8 percent	9 months 13 percent	22 months 30 percent

Source: GAO analysis of DOD data.

Notes: Data were obtained from DOD’s Selected Acquisition Reports. In a few cases data were obtained directly from program offices. Not all programs had comparable cost and schedule data and these programs were excluded from the analysis where appropriate. Portfolio performance data do not include costs of developing Missile Defense Agency elements. Total acquisition cost includes research and development, procurement, acquisition operation and maintenance, and system-specific military construction costs.

# Current and Baseline Cost Estimates for DOD's 2010 Portfolio of Major Defense Acquisition Programs

Table 5 contains the current and baseline total acquisition cost estimates (in fiscal year 2011 dollars) for each program or element in the Department of Defense's (DOD) 2010 major defense acquisition program portfolio. We excluded elements of the Missile Defense Agency's Ballistic Missile Defense System because comparable current and baseline cost estimates were not available. For each program we show the percent change in total acquisition cost from the program baseline, as well as over the past 2 years and 5 years.

**Table 5: Current Cost Estimates and Baseline Cost Estimates for DOD's 2010 Portfolio of Major Defense Acquisition Programs**

Fiscal year 2011 dollars in millions

Program	Current total acquisition cost	Baseline total acquisition cost	Change in total acquisition cost from baseline (%)	Change in total acquisition cost within the past 2 years (%)	Change in total acquisition cost within the past 5 years (%)
Advanced Extremely High Frequency (AEHF) Satellite	\$12,920	\$6,277	105.8	61.3	87.1
Advanced Threat Infrared Countermeasure/Common Missile Warning System (ATIRCM/CMWS)	4,701	3,362	39.8	-4.2	-1.6
AGM-88E Advanced Anti-Radiation Guided Missile (AARGM)	1,825	1,577	15.7	8.7	11.2
AH-64D Longbow Apache	14,507	6,041	140.2	15.4	38.9
AIM-120 Advanced Medium Range Air-to-Air Missile (AMRAAM)	23,900	10,767	122.0	30.8	41.7
AIM-9X/Air-to-Air Missile	3,589	3,096	15.9	7.2	16.2
Airborne Signals Intelligence Payload (ASIP)–Baseline	546	342	59.5	NA	NA
Apache Block III (AB3)	10,577	7,135	48.2	35.7	48.2
Army Integrated Air & Missile Defense (Army IAMD)	4,954	4,954	0.0	0.0	0.0
B-2 Extremely High Frequency (EHF) SATCOM Capability, Increment 1	619	699	-11.6	-8.3	-11.6
B-2 Radar Modernization Program (B-2 RMP)	1,305	1,319	-1.1	3.4	2.8
Black Hawk (UH-60M)	21,936	12,779	71.7	3.2	16.3
Block IV Tomahawk (Tactical Tomahawk)	6,845	2,085	228.3	49.2	50.9
Bradley Fighting Vehicle Systems (BFVS) A3 Upgrade	9,670	4,119	134.8	-5.8	200.4
Broad Area Maritime Surveillance (BAMS) Unmanned Aircraft System (UAS)	13,032	12,657	3.0	3.0	3.0

**Appendix III**  
**Current and Baseline Cost Estimates for**  
**DOD's 2010 Portfolio of Major Defense**  
**Acquisition Programs**

(Continued From Previous Page)

Fiscal year 2011 dollars in millions

Program	Current total acquisition cost	Baseline total acquisition cost	Change in total acquisition cost from baseline (%)	Change in total acquisition cost within the past 2 years (%)	Change in total acquisition cost within the past 5 years (%)
C-130 Avionics Modernization Program (C-130 AMP)	6,053	4,071	48.7	9.6	33.3
C-130J Hercules	15,327	935	1,539.3	22.2	117.4
C-17A Globemaster III	82,347	52,769	56.0	9.7	13.9
C-27J Joint Cargo Aircraft (JCA)	1,966	3,854	-49.0	-49.0	-49.0
C-5 Avionics Modernization Program (C-5 AMP)	1,320	1,087	21.5	-11.9	38.3
C-5 Reliability Enhancement and Reengining Program (C-5 RERP)	7,348	10,744	-31.6	-29.0	-30.4
CH-47F Improved Cargo Helicopter (CH-47F)	13,530	3,172	326.6	4.7	13.5
CH-53K—Heavy Lift Replacement	21,902	16,311	34.3	33.9	34.3
Chemical Demilitarization—Assembled Chemical Weapons Alternatives (Chem Demil-ACWA)	7,935	2,596	205.6	8.6	73.0
Chemical Demilitarization—Chemical Materials Agency (Chem Demil-CMA)	28,362	15,260	85.9	-4.7	0.1
Cobra Judy Replacement (CJR)	1,797	1,607	11.8	5.0	12.4
Cooperative Engagement Capability (CEC)	5,063	2,897	74.8	1.2	-0.1
CVN 21 Future Aircraft Carrier	34,186	35,048	-2.5	12.0	2.9
CVN-68 Class / Carrier Replacement Program (CVN 77)	6,873	5,948	15.6	-0.2	-3.5
DDG 1000 Destroyer	19,810	34,284	-42.2	-29.7	120.6
DDG 51 Destroyer	94,344	14,960	530.6	21.9	20.8
E-2D Advanced Hawkeye (E-2D AHE)	17,831	14,535	22.7	12.0	21.0
EA-18G Growler	11,601	8,843	31.2	32.6	32.3
EA-6B Improved Capability (ICAP) III	1,187	1,170	1.4	1.4	1.4
Excalibur Precision Guided Extended Range Artillery Projectile	2,437	4,706	-48.2	3.0	10.3
Expeditionary Fighting Vehicle (EFV)	14,044	9,019	55.7	0.6	14.6
Gray Eagle	4,978	1,000	397.7	108.6	397.7
F/A-18E/F Super Hornet	54,625	80,513	-32.2	3.4	7.7
F-22 Raptor	77,393	89,901	-13.9	2.9	6.8
F-35 Lightning II (Joint Strike Fighter)	283,674	210,558	34.7	13.6	23.9
Family of Advanced Beyond Line-of-Sight Terminals (FAB-T)	3,930	3,141	25.1	11.6	25.1
Family of Medium Tactical Vehicles (FMTV)	21,301	10,292	107.0	0.8	19.6
Force XXI Battle Command Brigade and Below (FBCB2)	4,113	2,785	47.7	13.8	102.3



**Appendix III**  
**Current and Baseline Cost Estimates for**  
**DOD's 2010 Portfolio of Major Defense**  
**Acquisition Programs**

(Continued From Previous Page)

Fiscal year 2011 dollars in millions

Program	Current total acquisition cost	Baseline total acquisition cost	Change in total acquisition cost from baseline (%)	Change in total acquisition cost within the past 2 years (%)	Change in total acquisition cost within the past 5 years (%)
Global Broadcast Service (GBS)	1,118	567	97.4	22.5	28.0
Global Hawk (RQ-4A/B)	13,576	5,312	155.5	37.2	92.7
Guided Multiple Launch Rocket System (GMLRS)	5,767	1,742	231.1	3.8	-53.8
H-1 Upgrades (UH-1Y/AH-1Z)	11,866	3,572	232.2	37.4	47.3
High Mobility Artillery Rocket System (HIMARS)	2,126	4,297	-50.5	0.5	-52.3
Increment 1 Early-Infantry Brigade Combat Team (E-IBCT)	3,077	3,184	-3.4	-3.4	-3.4
Integrated Defensive Electronic Countermeasures (IDECM) Block 4	692	684	1.2	1.2	1.2
Integrated Defensive Electronic Countermeasures (IDECM) Blocks 2/3	1,531	1,461	4.8	4.8	4.8
Joint Air-to-Surface Standoff Missile (JASSM)	7,201	2,282	215.6	23.6	50.5
Joint Direct Attack Munition (JDAM)	6,377	3,367	89.4	8.1	3.0
Joint High Speed Vessel (JHSV)	3,669	3,583	2.4	2.4	2.4
Joint Land Attack Cruise Missile Defense Elevated Netted Sensor System (JLENS)	7,378	6,567	12.4	7.9	12.4
Joint Mine Resistant Ambush Protected (MRAP)	36,375	22,792	59.6	59.6	59.6
Joint Precision Approach and Landing System (JPALS)	971	997	-2.6	-2.6	-2.6
Joint Primary Aircraft Training System (JPATS)	5,815	3,670	58.4	-0.5	2.5
Joint Standoff Weapon (JSOW) Baseline	2,205	2,813	-21.6	0.2	-0.6
Joint Standoff Weapon (JSOW) Unitary	3,125	5,015	-37.7	17.9	9.8
Joint Tactical Radio System (JTRS) Ground Mobile Radios (GMR)	15,868	17,165	-7.6	-6.3	-11.8
Joint Tactical Radio System (JTRS) Handheld, Manpack, and Small Form Fit (HMS)	4,786	9,889	-51.6	55.2	-51.6
Joint Tactical Radio System (JTRS) Network Enterprise Domain (NED)	1,995	966	106.4	-3.8	43.1
Airborne and Maritime/Fixed Station Joint Tactical Radio System (AMF JTRS)	8,212	8,033	2.2	2.2	2.2
Large Aircraft Infrared Countermeasures (LAIRCM)	454	397	14.4	14.4	14.4
Lewis and Clark Class (T-AKE) Dry Cargo/Ammunition Ship	6,586	5,205	26.5	16.8	35.7
LHA Replacement Amphibious Assault Ship	6,387	3,133	103.9	90.5	103.9
Light Utility Helicopter (LUH), UH-72A Lakota	1,969	1,784	10.4	-0.6	10.4

**Appendix III  
Current and Baseline Cost Estimates for  
DOD's 2010 Portfolio of Major Defense  
Acquisition Programs**

*(Continued From Previous Page)*

Fiscal year 2011 dollars in millions

<b>Program</b>	<b>Current total acquisition cost</b>	<b>Baseline total acquisition cost</b>	<b>Change in total acquisition cost from baseline (%)</b>	<b>Change in total acquisition cost within the past 2 years (%)</b>	<b>Change in total acquisition cost within the past 5 years (%)</b>
Littoral Combat Ship (LCS)	3,865	1,353	185.6	29.1	165.9
LPD 17 Amphibious Transport Dock	18,361	11,539	59.1	24.7	39.3
MH-60R Multi-Mission Helicopter	14,340	5,453	163.0	16.8	23.5
MH-60S Fleet Combat Support Helicopter	8,318	3,456	140.7	2.5	1.4
Minuteman III Propulsion Replacement Program (PRP)	2,913	2,775	5.0	0.1	1.1
Mobile User Objective System (MUOS)	6,830	6,622	3.1	4.4	14.6
Multifunctional Information Distribution System (MIDS)	2,939	1,284	129.0	9.1	21.0
Multi-Platform Radar Technology Insertion Program (MP-RTIP)	1,363	1,770	-23.0	0.1	-18.7
National Airspace System (NAS)	1,597	855	86.8	0.0	-1.2
National Polar-orbiting Operational Environmental Satellite System (NPOESS)	6,309	6,584	-4.2	-43.3	-13.9
Navstar Global Positioning System (GPS) IIIA	4,141	3,883	6.6	6.6	6.6
Navstar Global Positioning System (GPS) Space & Control	7,361	6,125	20.2	1.1	0.0
Navstar Global Positioning System (GPS) User Equipment	2,165	974	122.2	-1.0	49.6
Navy Multiband Terminal (NMT)	2,005	2,287	-12.3	0.6	-12.3
P-8A Poseidon	32,361	30,576	5.8	7.1	7.1
PATRIOT Advanced Capability-3 (PAC-3)	10,768	5,136	109.7	8.0	7.2
PATRIOT/Medium Extended Air Defense System (MEADS) Combined Aggregate Program (CAP) Fire Unit	18,513	19,077	-3.0	1.5	-0.4
PATRIOT/Medium Extended Air Defense System (MEADS) Combined Aggregate Program (CAP) Missile	7,677	7,179	6.9	10.4	9.2
Predator—Unmanned Aircraft System	3,581	3,579	0.1	0.1	0.1
Reaper Unmanned Aircraft System	11,132	2,598	328.5	328.5	328.5
Remote Minehunting System (RMS)	1,275	1,420	-10.2	-15.1	-10.2
Sea-Launched Ballistic Missile-UGM 133A Trident II (D-5) Missile	51,410	50,942	0.9	1.6	4.4
Space Based Infrared System (SBIRS) High Program	15,938	4,521	252.6	27.9	48.6
Space Based Space Surveillance (SBSS) Block 10	922	859	7.3	7.3	7.3

**Appendix III**  
**Current and Baseline Cost Estimates for**  
**DOD's 2010 Portfolio of Major Defense**  
**Acquisition Programs**

(Continued From Previous Page)

Fiscal year 2011 dollars in millions

Program	Current total acquisition cost	Baseline total acquisition cost	Change in total acquisition cost from baseline (%)	Change in total acquisition cost within the past 2 years (%)	Change in total acquisition cost within the past 5 years (%)
Standard Missile-6 (SM-6) Extended Range Active Missile (ERAM)	6,133	5,616	9.2	13.2	12.0
Stryker Family of Vehicles (Stryker)	16,153	7,914	104.1	-1.8	42.7
V-22 Joint Services Advanced Vertical Lift Aircraft (Osprey)	56,061	39,501	41.9	-1.1	3.3
Vertical Take-off and Landing Tactical Unmanned Aerial Vehicle (VTUAV)	2,469	2,576	-4.2	20.9	-4.2
Virginia Class Submarine (SSN 774)	82,193	59,550	38.0	-1.2	-7.8
Warfighter Information Network-Tactical (WIN-T) Increment 2	4,738	3,653	29.7	29.7	29.7
Warfighter Information Network-Tactical (WIN-T) Increment 3	13,552	16,125	-16.0	-16.0	-16.0
Warfighter Information Network-Tactical (WIN-T), Increment I	4,006	4,027	-0.5	-0.5	-0.5
Wideband Global SATCOM (WGS)	\$3,561	\$1,175	203.1	68.4	75.6

Source: GAO analysis of DOD data.

Notes: Data were obtained from DOD's SARs, acquisition program baselines, and, in some cases, program offices. NA indicates data were not available to make the assessment.

# Knowledge-Based Acquisition Practices

GAO’s prior work on best product development practices found that successful programs take steps to gather knowledge that confirms that their technologies are mature, their designs stable, and their production processes are in control. Successful product developers ensure a high level of knowledge is achieved at key junctures in development. We characterize these junctures as knowledge points. The Related GAO Products section of this report includes references to the body of work that helped us identify these practices and apply them as criteria in weapon system reviews. The following summarizes these knowledge points and associated key practices.

<b>Knowledge Point 1: Technologies, time, funding, and other resources match customer needs. Decision to invest in product development</b>
Demonstrate technologies to a high readiness level—technology readiness level 7—to ensure technologies will work in an operational environment
Ensure that requirements for product increment are informed by preliminary design review using systems engineering process (such as prototyping of preliminary design)
Establish cost and schedule estimates for product on the basis of knowledge from preliminary design using system engineering tools (such as prototyping of preliminary design)
Constrain development phase (5 to 6 years or less) for incremental development
Ensure development phase fully funded (programmed in anticipation of milestone)
Align program manager tenure to complete development phase
Contract strategy that separates system integration and system demonstration activities
Conduct independent cost estimate
Conduct independent program assessment
Conduct major milestone decision review for development start
<b>Knowledge Point 2: Design is stable and performs as expected. Decision to start building and testing production-representative prototypes</b>
Complete system critical design review
Complete 90 percent of engineering design drawing packages
Complete subsystem and system design reviews
Demonstrate with system-level integrated prototype that design meets requirements
Complete the failure modes and effects analysis
Identify key system characteristics
Identify critical manufacturing processes
Establish reliability targets and growth plan on the basis of demonstrated reliability rates of components and subsystems
Conduct independent cost estimate
Conduct independent program assessment
Conduct major milestone decision review to enter system demonstration

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**Knowledge Point 3: Production meets cost, schedule and quality targets. Decision to produce first units for customer**

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Demonstrate manufacturing processes

Build and test production-representative prototypes to demonstrate product in intended environment

Test production-representative prototypes to achieve reliability goal

Collect statistical process control data

Demonstrate that critical processes are capable and in statistical control

Conduct independent cost estimate

Conduct independent program assessment

Conduct major milestone decision review to begin production

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Source: GAO.

# Technology Readiness Levels

Technology readiness level	Description	Hardware/software	Demonstration environment
1. Basic principles observed and reported	Lowest level of technology readiness. Scientific research begins to be translated into applied research and development. Examples might include paper studies of a technology's basic properties	None (paper studies and analysis)	None
2. Technology concept and/or application formulated	Invention begins. Once basic principles are observed, practical applications can be invented. The application is speculative and there is no proof or detailed analysis to support the assumption. Examples are still limited to paper studies.	None (paper studies and analysis)	None
3. Analytical and experimental critical function and/or characteristic proof of concept	Active research and development is initiated. This includes analytical studies and laboratory studies to physically validate analytical predictions of separate elements of the technology. Examples include components that are not yet integrated or representative.	Analytical studies and demonstration of nonscale individual components (pieces of subsystem)	Lab
4. Component and/or breadboard validation in laboratory environment	Basic technological components are integrated to establish that the pieces will work together. This is relatively "low fidelity" compared to the eventual system. Examples include integration of "ad hoc" hardware in a laboratory.	Low-fidelity breadboard. Integration of nonscale components to show pieces will work together. Not fully functional or form or fit but representative of technically feasible approach suitable for flight articles.	Lab
5. Component and/or breadboard validation in relevant environment	Fidelity of breadboard technology increases significantly. The basic technological components are integrated with reasonably realistic supporting elements so that the technology can be tested in a simulated environment. Examples include "high fidelity" laboratory integration of components.	High-fidelity breadboard. Functionally equivalent but not necessarily form and/or fit (size weight, materials, etc). Should be approaching appropriate scale. May include integration of several components with reasonably realistic support elements/subsystems to demonstrate functionality.	Lab demonstrating functionality but not form and fit. May include flight demonstrating breadboard in surrogate aircraft. Technology ready for detailed design studies.

**Appendix V**  
**Technology Readiness Levels**

*(Continued From Previous Page)*

6. System/subsystem model or prototype demonstration in a relevant environment	Representative model or prototype system, which is well beyond the breadboard tested for TRL 5, is tested in a relevant environment. Represents a major step up in a technology's demonstrated readiness. Examples include testing a prototype in a high fidelity laboratory environment or in simulated realistic environment.	Prototype. Should be very close to form, fit and function. Probably includes the integration of many new components and realistic supporting elements/subsystems if needed to demonstrate full functionality of the subsystem.	High-fidelity lab demonstration or limited/restricted flight demonstration for a relevant environment. Integration of technology is well defined.
7. System prototype demonstration in a realistic environment	Prototype near or at planned operational system. Represents a major step up from TRL 6, requiring the demonstration of an actual system prototype in a realistic environment, such as in an aircraft, vehicle or space. Examples include testing the prototype in a test bed aircraft.	Prototype. Should be form, fit and function integrated with other key supporting elements/subsystems to demonstrate full functionality of subsystem.	Flight demonstration in representative realistic environment such as flying test bed or demonstrator aircraft. Technology is well substantiated with test data.
8. Actual system completed and "flight qualified" through test and demonstration	Technology has been proven to work in its final form and under expected conditions. In almost all cases, this TRL represents the end of true system development. Examples include developmental test and evaluation of the system in its intended weapon system to determine if it meets design specifications.	Flight-qualified hardware	Developmental Test and Evaluation (DT&E) in the actual system application.
9. Actual system "flight proven" through successful mission operations	Actual application of the technology in its final form and under mission conditions, such as those encountered in operational test and evaluation. In almost all cases, this is the end of the last "bug fixing" aspects of true system development. Examples include using the system under operational mission conditions.	Actual system in final form	Operational Test and Evaluation (OT&E) in operational mission conditions.

Source: GAO and its analysis of National Aeronautics and Space Administration data.



# Comments from the Department of Defense



ACQUISITION,  
TECHNOLOGY  
AND LOGISTICS

## OFFICE OF THE UNDER SECRETARY OF DEFENSE

3000 DEFENSE PENTAGON  
WASHINGTON, DC 20301-3000

MAR 11 2011

Mr. Michael J. Sullivan  
Director, Acquisition and Sourcing Management  
U.S. Government Accountability Office  
441 G Street, NW  
Washington, DC 20548

Dear Mr. Sullivan:

This is the Department of Defense (DoD) response to the GAO Draft Report, GAO-11-233SP, "DEFENSE ACQUISITIONS: Assessments of Selected Weapon Programs," dated January 31, 2011 (GAO Code 120920).

While the Department recognizes that program cost growth is a long-standing and unacceptable tendency, it does not find GAO's methods of calculating cost growth useful for management purposes. Although the Draft Report includes the cost and schedule growth metrics developed cooperatively among DoD, GAO, and OMB, we are concerned that GAO continues to publish performance metrics using its traditional methodology of measuring total program cost growth from Milestone B to the current year. This methodology has serious flaws that AT&L continues to highlight - cost growth that occurred in the 1990s, capability upgrades, and quantity increases are all summed together, producing misleading information. Some examples of questionable calculations in the Draft Report:

- The DDG-51 ship program grew in both quantity and capability since 2008, adding 9 ships with more robust missile defense. The Draft Report includes a program cost growth of almost \$17B, making DDG-51 appear to be one of the worst performing programs in the Department. Yet the quantity increase DoD reports (the 9 ships) accounts for most of this growth, along with some growth for additional capability to improve air and anti-missile defense and improve land attack. DoD considers this program to be very successful.
- The Joint Mine Resistant Ambush Protected (MRAP) vehicle is also listed in the Draft Report as showing significant cost growth; in fact, GAO reports it as the third largest contributor to cost growth over the last two years. Yet the Joint MRAP program is one of the Department's major acquisition success stories from the conflicts in Iraq and Afghanistan. During this time, the demand for the MRAP continued to rise, and in 2007 Secretary Gates declared it the DoD's highest priority

acquisition program. This resulted in a quantity increase of over 7,000 units and is the sole driver behind GAO's cost growth calculation for the MRAP. The program remained efficient, successfully managing the additional quantity and several capability upgrades, and even experiencing a small decrease in unit costs.

The fact that these "traditional metrics" have been highlighted in Table 2 and discussed in detail throughout the text is disappointing. In addition, the Draft Report now gives up to four different cost growth metrics for each program, making it extremely difficult for readers to gain a factual understanding of program performance. The Department again requests that all of GAO's "traditional metrics" be removed from the Report.


The Draft Report does make an effort to include metrics discussed in 2008 with DoD, OMB, and GAO and we appreciate this. However, these metrics still do not adequately capture cost growth that results solely from poor estimating and poor execution as opposed to other sources including changes in inventory goals and changes in requirements or capabilities. We again offer to work with GAO to develop better metrics of cost growth associated with poor estimating and program execution using unit cost, adjusted for quantity and/or capability changes unassociated with these problems. Our goal would be to use the same data and metrics so that all of us better understand the underlying information being reported for all programs.

To address cost growth where it is real and unacceptable in an era of constrained budgets, the Department is pursuing an Efficiency Initiative to manage defense dollars in a manner that is, to quote Secretary Gates at his May 8, 2010 speech at the Eisenhower Library, "respectful of the American taxpayer at a time of economic and fiscal distress." Secretary Carter issued "Better Buying Power" guidance in September 2010, directing the acquisition workforce to undertake 23 principal actions, organized in five areas, to obtain greater efficiency and productivity in defense spending.

There is every reason to believe the efficiencies we are seeking can be realized. It has taken years for excessive costs and unproductive overhead to creep into our business practices, but over the coming years we can work them out again.

The Department appreciates the opportunity to comment on the draft report. Technical comments are provided as an enclosure to this letter. My point of contact for this effort is Ms. Anne Twist, 703-614-5420.

Sincerely,

  
Dr. Nancy L. Spruill  
Director,  
Acquisition Resources & Analysis

Enclosure: As stated

# GAO Contact and Acknowledgments

GAO Contact

Michael J. Sullivan, (202) 512-4841 or [sullivanm@gao.gov](mailto:sullivanm@gao.gov)

Acknowledgments

Principal contributors to this report were Ronald E. Schwenn, Assistant Director; Raj C. Chitikila; Deanna R. Laufer; Alan D. Rozzi; and Wendy P. Smythe. Other key contributors included David B. Best, Maricela Cherveney, Bruce D. Fairbairn, Arthur Gallegos, William R. Graveline, Kristine R. Hassinger, Michael J. Hesse, Meredith A. Kimmett, C. James Madar, Stephen P. Marchesani, Jean L. McSween, Kenneth E. Patton, Charles W. Perdue, W. Kendal Roberts, Rae Ann H. Sapp, Roxanna T. Sun, Robert S. Swierczek, Bruce H. Thomas, and Karen S. Zuckerstein.

The following were responsible for individual programs:

System	Primary staff
Advanced Extremely High Frequency (AEHF) Satellite	Bradley L. Terry
AGM-88 Advanced Anti-Radiation Guided Missile (AARGM)	Kathryn M. Edelman, Grant M. Sutton
Air and Missile Defense Radar (AMDR)	Molly W. Traci
Apache Block III (AB3)	Helena Brink
Army Integrated Air and Missile Defense (Army IAMD)	Carol T. Mebane, Ryan D. Stott
B-2 Defensive Management System (DMS) Modernization	Matthew P. Lea, Sean D. Merrill
B-2 Extremely High Frequency (EHF) SATCOM Capability, Increment 1	Sean D. Merrill, Don M. Springman
B-2 Extremely High Frequency (EHF) SATCOM Capability, Increment 2	Don M. Springman, Sean D. Merrill
BMDS: Airborne Laser Test Bed (ALTB)	LaTonya D. Miller
BMDS: Flexible Target Family (FTF)	Ivy G. Hubler, Teague A. Lyons
BMDS: Ground-Based Midcourse Defense (GMD)	Steven B. Stern, Rebecca Guerrero
BMDS: Terminal High Altitude Area Defense (THAAD)	Meredith A. Kimmett, Brian A. Tittle
Broad Area Maritime Surveillance (BAMS) Unmanned Aircraft System (UAS)	W. William Russell, Jodi G. Munson
C-130 Avionics Modernization Program (C-130 AMP)	Lauren M. Heft, Kathy Hubbell
C-27J Joint Cargo Aircraft (JCA)	Andrew H. Redd
C-5 Reliability Enhancement and Reengining Program (C-5 RERP)	Cheryl K. Andrew, Megan L. Hill
CH-53K - Heavy Lift Replacement	Marvin E. Bonner, Robert K. Miller
CVN 21 Future Aircraft Carrier	W. Kendal Roberts, Robert P. Bullock
DDG 1000 Destroyer	Deanna R. Laufer, W. Kendal Roberts
DDG 51 Destroyer	Molly W. Traci

**Appendix VII**  
**GAO Contact and Acknowledgments**

*(Continued From Previous Page)*

<b>System</b>	<b>Primary staff</b>
Defense Weather Satellite System (DWSS)	Maricela Cherveney
E-2D Advanced Hawkeye (E-2D AHE)	Jeffrey L. Hartnett, Teague A. Lyons
Enhanced Polar System (EPS)	Bradley L. Terry
Excalibur Precision Guided Extended Range Artillery Projectile	Wendy P. Smythe
Expeditionary Fighting Vehicle (EFV)	Jerry W. Clark, MacKenzie H. Cooper
F-22A Raptor	Andrew H. Redd, Michael W. Aiken
F-35 Lightning II (Joint Strike Fighter)	Charlie Shivers, LeAnna Parkey
Family of Advanced Beyond Line-of-Sight Terminals (FAB-T)	Scott Purdy, Alexandra K. Dew
Global Hawk (RQ-4A/B)	Laura Jezewski, Travis J. Masters
Global Positioning System (GPS) IIIA	Laura T. Holliday, Laura Hook, Sigrid McGinty
GPS III OCX Ground Control Segment	Arturo Holguin, Jr.
Gray Eagle	Tana M. Davis
H-1 Upgrades (UH-1Y/AH-1Z)	Stephen V. Marchesani
Increment 1 Early-Infantry Brigade Combat Team (E-IBCT)	Marcus C. Ferguson, Tana M. Davis
Intelligent Munitions System—Scorpion	Wendy P. Smythe, John S. Warren
Joint Air-to-Ground Missile (JAGM)	Carrie W. Rogers
Joint Air-to-Surface Standoff Missile (JASSM)	John W. Crawford, Michael J. Hesse
Joint High Speed Vessel (JHSV)	J. Kristopher Keener, Erin E. Preston
Joint Land Attack Cruise Missile Defense Elevated Netted Sensor System (JLENS)	John M. Ortiz
Joint Light Tactical Vehicle (JLTV)	Danny G. Owens, Dayna L. Foster
Joint Precision Approach and Landing System (JPALS)	W. Kendal Roberts
Airborne and Maritime/Fixed Station Joint Tactical Radio System (AMF JTRS)	Paul G. Williams
Joint Tactical Radio System (JTRS) Ground Mobile Radios (GMR)	Nathan A. Tranquilli, Ridge C. Bowman
Joint Tactical Radio System (JTRS) Handheld, Manpack, and Small Form Fit (HMS)	Nathan A. Tranquilli, Ridge C. Bowman
KC-X Program	Wendell K. Hudson, Mary Jo Lewnard
LHA Replacement Amphibious Assault Ship (LHA 6)	Celina F. Davidson
Littoral Combat Ship (LCS)	John P. Dell'Osso, Christopher R. Durbin
Littoral Combat Ship-Mission Modules	Gwyneth B. Woolwine, Jeremy Hawk, Christopher R. Durbin
Maritime Prepositioning Force (Future)/Mobile Landing Platform	Erin E. Preston, J. Kristopher Keener
Mobile User Objective System (MUOS)	Richard Y. Horiuchi
National Polar-orbiting Operational Environment Satellite System (NPOESS)	Suzanne Sterling
Navy Multiband Terminal (NMT)	Lisa P. Gardner
Navy Unmanned Combat Air System Aircraft Carrier Demonstration (UCAS-D)	Julie C. Hadley, Travis J. Masters
Nett Warrior Increment 1	William C. Allbritton

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**Appendix VII**  
**GAO Contact and Acknowledgments**

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*(Continued From Previous Page)*

<b>System</b>	<b>Primary staff</b>
Ohio-Class Replacement (OR)/Sea Based Strategic Deterrent	Alan D. Rozzi, C. James Madar
P-8A Poseidon	Heather L. Miller, Jacob L. Beier
PATRIOT/Medium Extended Air Defense System (MEADS) Combined Aggregate Program (CAP) Fire Unit	Ryan D. Stott, Carol T. Mebane
Reaper Unmanned Aircraft System	Rae Ann H. Sapp
Ship to Shore Connector (SSC)	Meghan Hardy, Kelly Bradley
Small Diameter Bomb (SDB), Increment II	Michael J. Hesse
Space Based Infrared System (SBIRS) High Program	Claire Buck
Space Fence	Peter E. Zwanzig
Standard Missile-6 (SM-6) Extended Range Active Missile (ERAM)	Angie Nichols-Friedman, Deanna R. Laufer
Stryker Modernization (SMOD)	Andrea M. Bivens, Wendy P. Smythe
Three Dimensional Expeditionary Long Range Radar (3DELRR)	Anne McDonough-Hughes, Amy Moran Lowe
V-22 Joint Services Advanced Vertical Lift Aircraft (Osprey)	Bonita P. Oden, Jerry W. Clark
Presidential Helicopter (VXX)	J. Andrew Walker, Michael W. Aiken
Vertical Take-off and Landing Tactical Unmanned Aerial Vehicle (VTUAV)	Leigh Ann Nally
Virginia Class Submarine (SSN 774)	C. James Madar, Alan D. Rozzi
Warfighter Information Network-Tactical (WIN-T) Increment 2	James P. Tallon
Warfighter Information Network-Tactical (WIN-T) Increment 3	James P. Tallon

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Source: GAO.

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# Related GAO Products

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*Defense Acquisitions: Observations on Weapon Program Performance and Acquisition Reforms.* [GAO-10-706T](#). Washington, D.C.: May 19, 2010.

*Defense Acquisitions: Strong Leadership Is Key to Planning and Executing Stable Weapon Programs.* [GAO-10-522](#). Washington, D.C.: May 6, 2010.

*Best Practices: DOD Can Achieve Better Outcomes by Standardizing the Way Manufacturing Risks Are Managed.* [GAO-10-439](#). Washington, D.C.: April 22, 2010.

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*Best Practices: Better Matching of Needs and Resources Will Lead to Better Weapon System Outcomes.* [GAO-01-288](#). Washington, D.C.: March 8, 2001.



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*Best Practices: A More Constructive Test Approach Is Key to Better Weapon System Outcomes.* [GAO/NSIAD-00-199](#). Washington, D.C.: July 31, 2000.

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*Best Practices: Successful Application to Weapon Acquisition Requires Changes in DOD's Environment.* [GAO/NSIAD-98-56](#). Washington, D.C.: February 24, 1998.

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